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(54) Airport surface monitoring and runway incursion warning system

(57) An airport runway incursion warning system (10) for monitoring air and ground traffic at an airport. The system (10) is optimally used with an aircraft (12) that has an electronic tag (21) or interrogation system (21) that stores identification information regarding the aircraft (12), and an RF transponder (22) for receiving interrogation signals and for transmitting the identification information in response thereto. A radar system (41, 20) comprises a plurality of radar sensor units (13) disposed at predetermined installation sites adjacent to a runway (11). Each radar sensor unit (13) typically has an interface processor (42, 14) and telemetry electronics (43, 14a) for communication, although hard-wired communication paths may be used. An RF/telemetry interface (43, 18) is provided for communicating with the radar sensor units (13) when the interface processor (42, 14) and telemetry electronics (43, 14a) are used. The RF/telemetry interface (43, 18) is also used to transmit the interrogation signals to the aircraft (12) and receive the identification information therefrom. A central processing unit (44, 16) is coupled to the radar sensor units (13) for receiving and integrating radar data produced by each the radar sensor units (13) to produce a map of the runway (11) that identifies authorization objects (26) and aircraft (12) that do not constitute intrusion threats, and intruding objects that do constitute intrusion threats to the runway (11). The central processing unit (44, 16) is optionally coupled to the RF/telemetry interface (43, 18) for transmitting signals to and from the aircraft (12), and in this case, the central processing unit (44, 16) processes identification information received from the aircraft (12) to integrate the identification information into to generate a displayed image. An operator display (45, 17) is coupled to the central processing unit (44, 16) for displaying the map and identification information generated thereby for use by an operator.

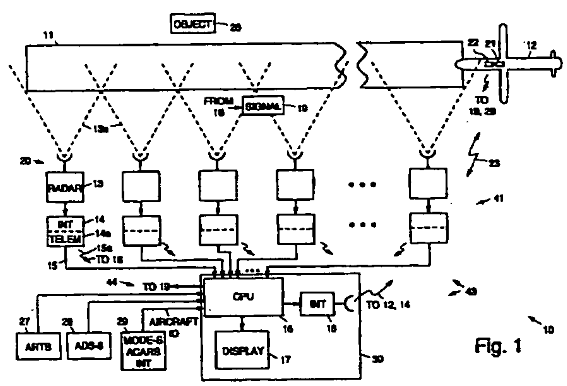

Fig. 1

EP 0 744 630 A2

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Description

BACKGROUND

The present invention relates to radar systems, and more particularly, to a radar system that is used to provide surface monitoring and runway incursion for airports.

The prevention of runaway incursions has been an issue of increasing concern and has resulted in the development of the Airport Surface Detection Equipment (ASDE-3), the Airport Movement Area System (AMASS), and the Airport Surface Traffic Automation Program (ASTA).

The most relevant prior art relating to the present invention, and airport surface monitoring and runway incursion systems in particular is the ASDE-3 radar system which is a single high power Ku-Band real aperture radar that is located on a tower adjacent to an airport. The ASDE-3 system experiences shadowing and multiple reflections that seriously affect the its performance, which is a consequence of the fact that it is a single radar system. The ASDE-3 radar system does not have the ability to interrogate vehicles or aircraft monitored by the system. The ASDE-3 radar system is also relatively expensive.

Therefore, it is an objective of the present invention to provide for an improved radar system that may be used to monitor surface and runway incursion at airports, and the like, and which improves upon the currently-used ASDE-3 radar system.

SUMMARY OF THE INVENTION

In order to meet the above and other objectives, the present invention is a runway incursion warning system for monitoring a runway of an airport and for displaying data indicative of unauthorized intrusion onto the runway to an operator. A radar system is provided that comprises a plurality of radar sensor units that are disposed at predetermined installation sites adjacent to selected runways of the airport. Each radar sensor unit associated with a particular runway generates a radar beam that typically overlaps the adjacent radar beam to provide complete coverage of a runway. Each radar sensor unit is coupled to a collocated interface processor and telemetry electronics that interface between the radar sensor unit and a central processing unit. Communication between each radar sensor unit and the central processing unit may be by physical electrical interconnection and/or RF communication using the telemetry electronics. The physical electrical interconnection may be provided by way of existing cabling normally for runway lights to provide power and the communication link for each of the radar sensor units.

The central processing unit is coupled to an operator display that processed data derived from each of the radar sensor units and displays the data on the operator display. The central processing unit is coupled to an RF/telemetry interface that is used to communicate with the radar sensor units and to aircraft having an electronic tag or transponder system. The central processing unit also integrates and causes the display of data derived from other systems coupled to it, such as the ARTS, ASDE-3, MODE-S or ACARS systems, for example. The central processing unit also generates a display showing the airport runways along with moving and non-moving physical objects that are in the vicinity of the runway. Such objects include departing and arriving aircraft, buildings, and vehicles that are in the vicinity of the runway. Thus, the present system provides a complete display of the runway environment to an operator.

The system may be used with non-cooperative objects or vehicles, or with aircraft or vehicles that have the electronic tag or RF transponder (transmitter and receiver) system. The electronic tag or RF transponder system contains identification information regarding the aircraft, vehicle, or object. The tag or RF transponder receives interrogation signals and transmits the identification information, and other additional information, if desired, in response to the interrogation signals.

The interface processor and telemetry electronics at each radar sensor unit and the RF/telemetry interface provide a communication link between the radar sensor units and the central processing unit. The RF/telemetry interface transmits the interrogation signals and receives the identification information from the aircraft and other cooperative objects or vehicles. Alternatively, the identification information may be received by a central receiver at the airport while the RF/telemetry interface only transmits interrogation signals in conformance with existing aircraft equipment, such as MODE-S or ACARS systems, for example. Multiple interrogation signals sent by different sensor units are separated and identified on the basis of timing, for example, for reception of identifications signals or GPS position information contained in the identification signals themselves.

The telemetry electronics receives data produced by the radar sensor units and the central processing unit integrates the data derived from the radar sensor units and the electronic tag or transponder system in the aircraft. The central processing unit processes data derived from the radar system and identification information received from the electronic tag to produce a map of the airport that identifies authorization objects and aircraft that are not intrusion threats, and intruding objects that are intrusion threats. The operator display displays the map generated by the central processing unit.

The central processing unit generates warning signals in response to intrusion threats that are detected by the system and wherein the warning signals are transmitted to the aircraft by means of the RF/telemetry interface and the RF transponder system. The central processing unit generates an image of the runways that identifies objects, aircraft that are landing and taking off from the runways, and identifying information associ-

ated with interrogated aircraft derived from the electronic tag or transponder system. The central processing unit may also produce data that is displayed on the map that includes priority alert information indicating aircraft that may impose a possible runway incursion, a list of arriving and departing aircraft, and displays that show landing and take-off patterns of arriving and departing aircraft.

The system thus provides for a distributed system of relatively low-cost radars disposed adjacent the runways. Each radar has limited angular coverage and the complete system provides coverage of the entire airport runway area. The present system provides a surface map of aircraft and surface vehicles and point interrogation of aircraft for identification purposes using the electronic tags or transponder system.

The present runway incursion warning system is considerably less expensive than the ASDE-3 radar system, and does not suffer from the shadowing and multiple reflection problems experienced by the ASDE-3 system. The system is scalable to provide monitoring of different size airports. The system provides high range resolution and velocity information, and may be used to interrogate electronic tags or transponder systems disposed on vehicles and aircraft to provide identification information to aircraft traffic controllers that operate the system. The system provides a real-time display of airport surface traffic and warnings of runway incursion.

BRIEF DESCRIPTION OF THE DRAWINGS

The various features and advantages of the present invention may be more readily understood with reference to the following detailed description taken in conjunction with the accompanying drawing, wherein like reference numerals designate like structural elements, and in which:

Fig. 1 illustrates a system block diagram of a runway incursion warning system in accordance with the principles of the present invention; and

Fig. 2 illustrates a typical video display produced by the runway incursion warning system of Fig. 1.

DETAILED DESCRIPTION

Referring to the drawing figure, Fig. 1 illustrates a system block diagram of a runway incursion warning system 10 in accordance with the principles of the present invention. The system 10 includes a radar system 20 that is comprised of a plurality of radar sensor units 13, such as millimeter wave radar sensor units 13, for example, disposed at predetermined installation sites on the ground adjacent to a runway 11, or runways 11, of an airport. Each radar sensor unit 13 associated with a particular runway 11 generates a radar beam 13a that typically overlaps the adjacent radar beam 13a to provide complete coverage of a runway 11, although this is not absolutely required. Each radar sensor unit 13 is coupled to an interface processor (INT) 14 and telemetry electronics (TELEM) 14a that permit communication with a processing center 30 located in an airport control tower, for example. Intelligent processing may be performed at each installation site in the interface processor 14 to reduce the data rate of telemetered data and perform confidence tests. Existing cabling 15 for airport lights provide power and a communication link for each of the plurality of radar sensor units 13, interface processor 14, and telemetry electronics 14a. Alternatively, a dedicated RF communications link 15a may be employed.

A central processing unit (CPU) 16 integrates the data received from the plurality of radar sensor units 13, and maintains a map of authorized targets 26, such as fixed objects 26 or buildings 26 that do not constitute intrusion threats. The central processing unit 16 may also collect input data from an ARTS or ASDE-3 system 27 and available identification reports derived therefrom. The ARTS and ASDE-3 systems provide information regarding aircraft approaching the airport. Data that is derived from an ASDE-3 radar 28, if available, may also be integrated by the central processing unit 16, and a dynamic real-time situation display 17 is provided to an aircraft controller, in graphic format, that is clear and easy to interpret. A sample image on the video display 17 that is presented to an operator of the system 10 is shown in Fig. 2.

The aircraft 12 includes an electronic tag or interrogation system 21 such as a MODE-S or ACARS transponder system 21, for example, that provides identification information regarding the aircraft, and an RF transponder system 22. Warning signals may be transmitted to the aircraft 12 by means of the RF/telemetry interface 18 and the RF transponder system 22 over an RF communications link 23. Warning signals may also be displayed to arriving and departing aircraft 12 using ground signals 19 such as lights or beacons disposed adjacent the runway 11. In addition, the electronic tag or interrogation system 21 may be interrogated by the system 10 using the RF/telemetry interface 18 and the RF transponder system 22. Interrogation signals are transmitted to the aircraft 12 by way of the communication link 23, and the electronic tag or interrogation system 21 on the aircraft 12 responds by outputting information stored therein that is returned to the central processing unit 16 by way of the RF communications link 23.

As shown in Fig. 1, the system 10 is comprised of five major subsystems 41-45. The first subsystem 41 comprises the radar system 20 including the plurality of radar sensor units 13 and electronic components installed at each installation site. The second subsystem 42 comprises the interface processor 14 that is coupled to the radar sensor units 13 and that is located at each remote installation site. The third subsystem 43 comprises a telemetry subsystem and includes the telemetry electronics 14a installed at the installation

sites and an RF/telemetry interface 18 that is coupled to the central processing unit 16 at the central processor site. The fourth subsystem 44 comprises the central processing unit 16. The fifth subsystem 45 comprises the operator display 17 that includes a conventional display and control terminal. Each of the subsystems 41-45 employed in the present invention are well-known and their interconnection and operation is routine to those skilled in the art.

The operator display 17 used in the runway incursion warning system 10 displays information for use by an airport traffic planner or aircraft traffic controller. The data presented on the operator display 17 optimizes the available data while minimizing the need for physical interaction with the system 10. Fig. 2 illustrates a typical video image displayed on the operator display 17 by the runway incursion warning system 10. Referring to Fig. 2, the display 17 shows an image of the runways 11 of the airport and identifies the locations of buildings 26 and other stationary objects 26, aircraft 12 that are landing and taking off from the runways 11, including data 47 from the transponders 21 from interrogated aircraft 12. Typically the data 47 from each transponder system 21 indicates the aircraft number or flight number, as is indicated by the alphanumeric identifiers in the boxes shown on the display 17. Additional data may be displayed including information provided in a system area 51 that provides data regarding the instrument landing system (ILS) system, the time and other relevant system parameters, priority alert information 52 indicating objects 26 or aircraft 12 that are determined to be runway incursions, a list 53 of arriving and departing aircraft 12, and displays 34 that provide real-time images showing the landing and take-off of arriving and departing aircraft 12.

A preliminary proof-of-concept demonstration model of the present system 10 was constructed and data collection was performed at Los Angeles International Airport (LAX) using a test version of a millimeter-wave radar (radar sensor units 13) developed by the assignee of the present invention. Test results show that the system 10 works as expected and provides superior performance over the ASDE-3 radar system.

In summary, there is disclosed an airport runway incursion warning system 10 for monitoring air and ground traffic at an airport. The system 10 is optimally used with an aircraft 12 that has an electronic tag 21 or interrogation system 21 that stores identification information regarding the aircraft 12, and an RF transponder 22 for receiving interrogation signals and for transmitting the identification information in response thereto. A radar system 41, 20 comprises a plurality of radar sensor units 13 disposed at predetermined installation sites adjacent to a runway 11. Each radar sensor unit 13 typically has an interface processor 42, 14 and telemetry electronics 43, 14a for communication, although hard-wired communication paths may be used. An RF/telemetry interface 43, 18 is provided for communicating with the radar sensor units 13 when the interface processor 42, 14 and telemetry electronics 43, 14a are used. The RF/telemetry interface 43, 18 is also used to transmit the interrogation signals to the aircraft 12 and receive the identification information therefrom. A central processing unit 44, 16 is coupled to the radar sensor units 13 for receiving and integrating radar data produced by each the radar sensor units 13 to produce a map of the runway 11 that identifies authorization objects 26 and aircraft 12 that do not constitute intrusion threats, and intruding objects that do constitute intrusion threats to the runway 11. The central processing unit 44, 16 is optionally coupled to the RF/telemetry interface 43, 18 for transmitting signals to and from the aircraft 12, and in this case, the central processing unit 44, 16 processes identification information received from the aircraft 12 to integrate the identification information into to generate a displayed image. An operator display 45, 17 is coupled to the central processing unit 44, 16 for displaying the map and identification information generated thereby for use by an operator.

Thus there has been described a new and improved radar system for providing surface monitoring and runway incursion for airports. It is to be understood that the above-described embodiments are merely illustrative of some of the many specific embodiments that represent applications of the principles of the present invention.

Clearly, numerous and other arrangements can be readily devised by those skilled in the art without departing from the scope of the invention.

Claims

1. An airport runway incursion warning system (10) for monitoring air and ground traffic in the vicinity of a runway (11) of an airport, said system (10) characterized by:

   a radar system (41, 20) comprising of a plurality of radar sensor units (13) disposed at predetermined installation sites adjacent to the runway (11) and wherein the plurality of radar sensor units (13) generate adjacent or substantially overlapping radar beams (13a) that illuminate the runway (11);

   a central processing unit (44, 16) coupled to the plurality of radar sensor units (13), for receiving radar data produced by the plurality of radar sensor units (13), and for processing the radar data to produce a map of the runway (11) that identify objects (26) and aircraft (12) in the vicinity thereof;

   an operator display (45, 17) coupled to the central processing unit (44, 16) for displaying the map of the runway (11), objects (26) and aircraft (12) generated by the central processing unit (44, 16).

2. The system (10) of Claim 1, characterized in that each radar sensor unit (13) is coupled to an interface processor (42, 14) for processing radar data generated by the radar sensor unit (13), wherein

each interface processor (42, 14) is coupled to RF telemetry electronics (43, 14a) for transmitting the radar data to the central processing unit (44, 16), and wherein the central processing unit (44, 16) is coupled to an RF/telemetry interface (43, 18) for receiving the radar data transmitted from the radar sensor unit (13) by the RF telemetry electronics (43, 14a).

3. The system (10) of Claim 2, characterized in that the aircraft (12) comprises an electronic tag (21) that stores identification information regarding the aircraft (12), and comprises an RF transponder (22) coupled to the electronic tag (21) for receiving interrogation signals generated by the central processing unit (44, 16) and for transmitting the identification information in response to the interrogation signals;

and wherein the interrogation signals generated by the central processing unit (44, 16) are transmitted to the aircraft (12) by way of the RF/telemetry interface (43, 18), and the identification information is received from the RF transponder (22) by way of the RF/telemetry interface (43, 18) and wherein the central processing unit (44, 16) generates signals for display on the operator display (45, 17) that identifies the aircraft (12).

4. The system (10) of Claim 2 or 3, characterized in that the central processing unit (44, 16) is coupled to the plurality of radar sensor units (13) by way of a RF communications link (43, 15a) for communicating radar to the central processing unit (44, 16) by way of the RF/telemetry interface (43, 18).

5. The system (10) of any of Claims 1-4, characterized further by an ARTS system (27) coupled to the central processing unit (44, 16), and wherein the central processing unit (44, 16) processes data and identification reports derived from the ARTS system (27) and integrates them into the map that is displayed on the operator display (45, 17).

6. The system (10) of any of Claims 1-5, further characterized by an ASDE-3 radar (28) coupled to the central processing unit (44, 16) and wherein the central processing unit (44, 16) integrates data derived from the ASDE-3 radar (28) into the map that is displayed on the operator display (45, 17).

7. The system (10) of any of Claims 3-6, characterized in that the central processing unit (44, 16) generates an image of the runway (11) that identifies objects (26), aircraft (12) that are landing and taking off from the runway (11), and identifying information (47) associated with interrogated aircraft (12) derived from the transponder (21).

8. The system (10) of any of Claims 3-7, characterized in that the central processing unit (44, 16) produces data for display that includes priority alert information (51) indicating aircraft (12) that are runway incursions, a list (53) of arriving and departing aircraft (12), and displays (54) that show landing and take-off patterns of arriving and departing aircraft (12).

9. The system (10) of any of Claims 3-8, characterized in that the central processing unit (44, 16) generates warning signals (19) in response to intrusion threats that are detected and wherein the warning signals (19) are transmitted to the aircraft (12) by means of the RF/telemetry interface (43, 18) and the RF transponder (22).

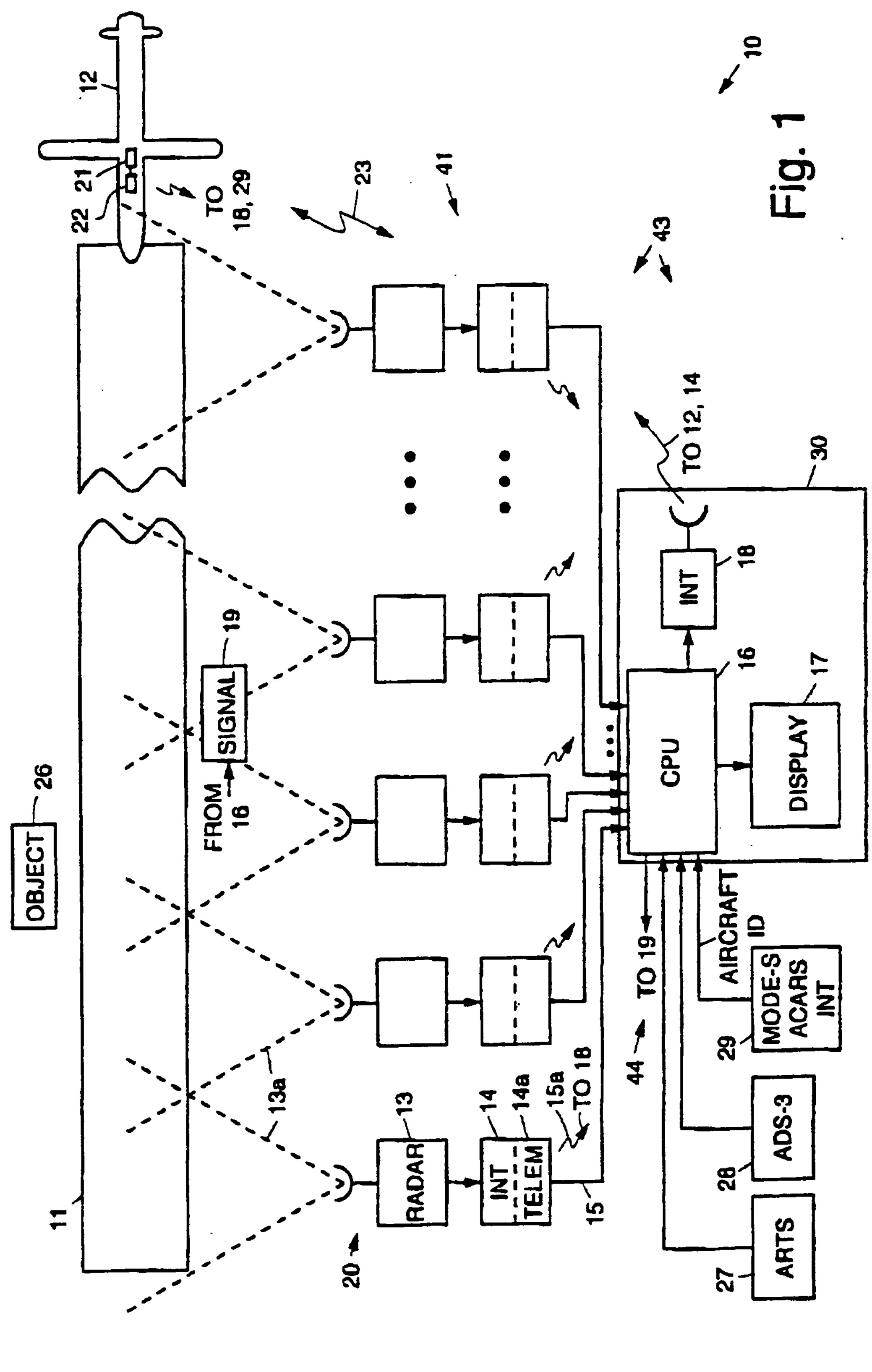
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Fig. 1

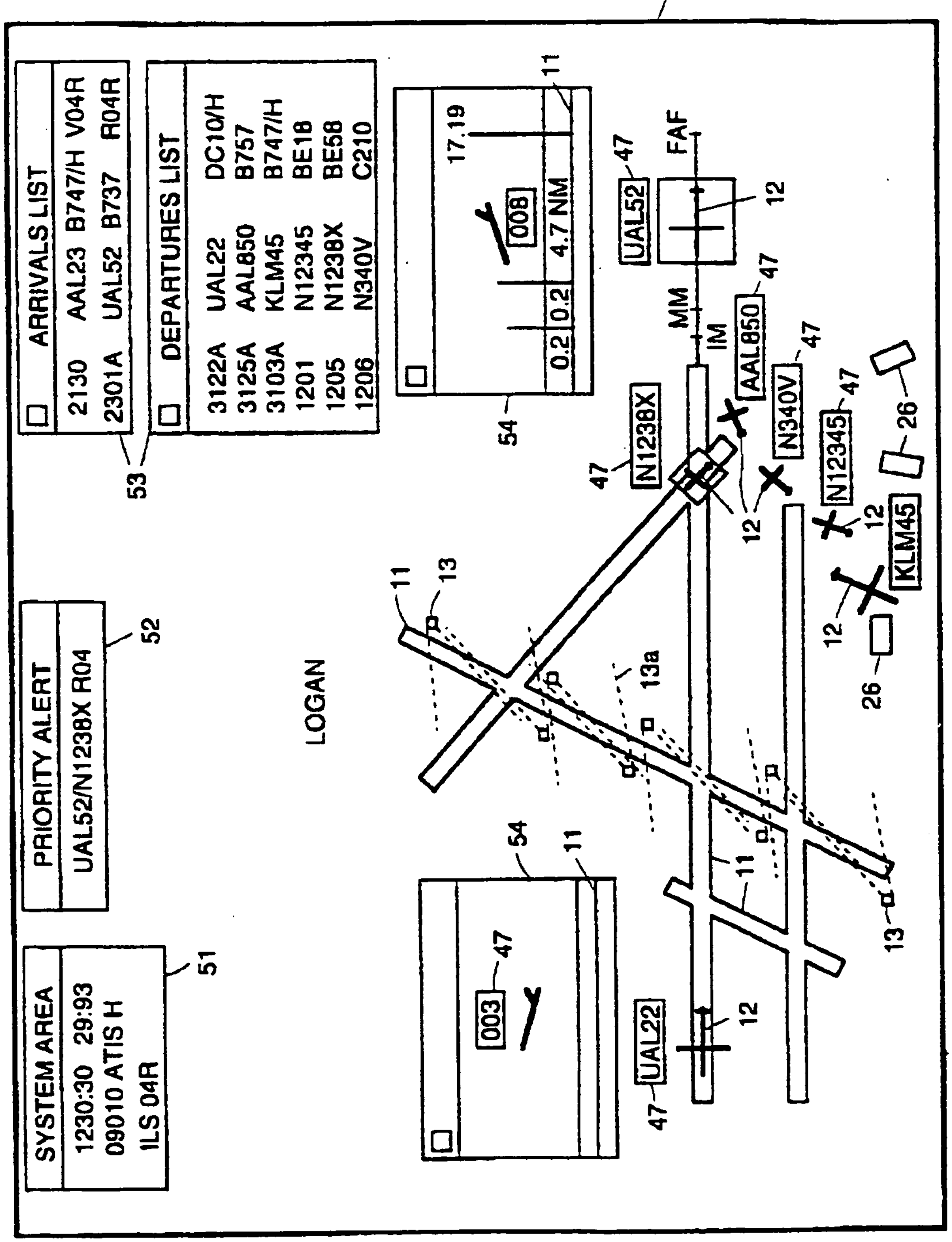
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Fig. 2

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(54) **Airport surface monitoring and runway incursion warning system**

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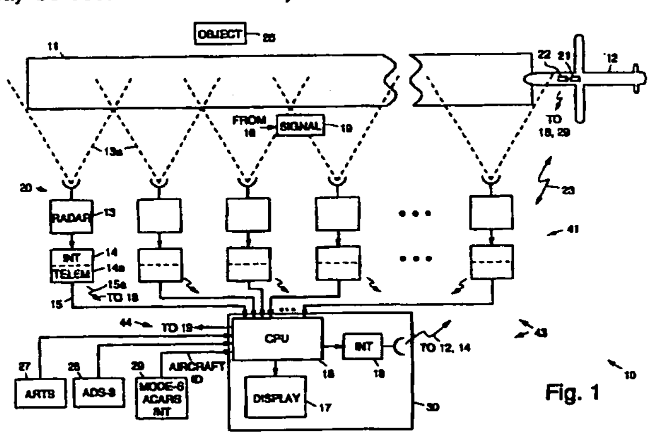

Fig. 1

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European Patent Office

EUROPEAN SEARCH REPORT

Application Number
EP 96 10 8293

Category	DOCUMENTS CONSIDERED TO BE RELEVANT Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int.Cl.6)
X Y	ATUL JAIN: "APPLICATIONS OF MILLIMETER-WAVE RADARS TO AIRPORT SURFACE SURVEILLANCE" DIGITAL AVIONICS SYSTEMS CONFERENCE, PHOENIX, OCT. 30 - NOV. 3, 1994, no. CONF. 13, INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS, pages 528-533, XP000512920 * page 528, left-hand column - page 531, left-hand column * * page 533, left-hand column - right-hand column; figures * ---	1-6 7-9	G01S13/91 G01S13/93 G01S7/06 G08G5/00 G08G5/06
Y	US 5 374 932 A (WYSCHOGROD DANIEL ET AL) 20 December 1994 * column 6 - column 7 * * column 10 - column 34 * ---	7,8	
Y	GO G ET AL: "ENHANCED AIRPORT SURFACE SURVEILLANCE RADAR" DIGITAL AVIONICS SYSTEMS CONFERENCE, PHOENIX, OCT. 30 - NOV. 3, 1994, no. CONF. 13, INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS, pages 544-551, XP000512923 * page 550 * ---	9	TECHNICAL FIELDS SEARCHED (Int.Cl.6) G01S G08G
A	EP 0 220 752 A (DRIM LTD) 6 May 1987 * column 4 - column 9; figures * ---	1-9	
A	DE 36 40 401 A (SIEMENS) 9 June 1988 * column 11, line 36 - line 51 * * column 2 - column 3 * ---	1	
A	US 3 872 474 A (LEVINE) 18 March 1975 * abstract; figures * --- -/--	1	

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
THE HAGUE	15 October 1997	Devine, J

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
Y : particularly relevant if combined with another document of the same category
A : technological background
O : non-written disclosure
P : intermediate document

T : theory or principle underlying the invention
E : earlier patent document, but published on, or after the filing date
D : document cited in the application
L : document cited for other reasons

& : member of the same patent family, corresponding document

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European Patent Office

EUROPEAN SEARCH REPORT

Application Number
EP 96 10 8293

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int.Cl.6)
A	EP 0 466 239 A (HAAN FRANS HERMAN DE) 15 January 1992 -----		

TECHNICAL FIELDS SEARCHED (Int.Cl.6)

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THE HAGUE	15 October 1997	Devine, J

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D : document cited in the application
L : document cited for other reasons

& : member of the same patent family, corresponding document

EPO FORM 1503 03.82 (P04C01)

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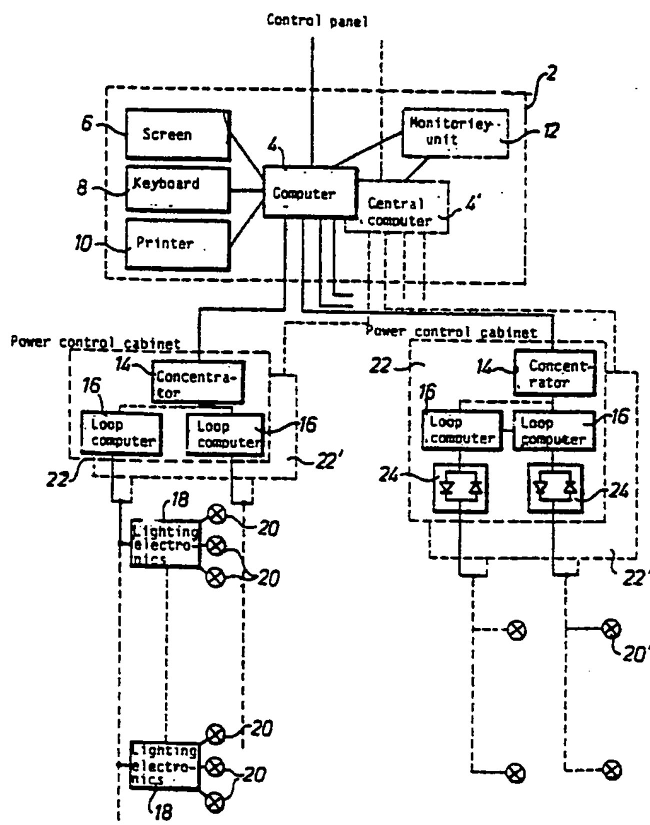
Published
With international search report.
In English translation (filed in Swedish).

(54) Title: SUPERVISION AND CONTROL OF AIRPORT LIGHTING AND GROUND MOVEMENTS

(57) Abstract

In a method and plant for supervising and controlling field lighting (20) at an airport, a regulator provided with a monitoring unit for power supply and monitoring the lighting fitting is arranged individually for each lighting (18, 20), such as to regulate the light intensity of the lighting and for receiving information as to its operational status. Each lighting in the plant is provided with a lighting electronic unit including a regulator, monitoring unit and modem for power supply to the light source and monitoring the operation of the lighting, each lighting being individually addressable from a control central for the airport. In the method and plant in accordance with the above, a ground traffic control system can be integrated in the field lighting system by connecting suitable presence detectors to the system.



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Supervision and Control of Airport Lighting and Ground Movements.

The present invention relates to a method and a plant for supervising and controlling field lighting at an airport, and which optionally include presence detectors.

The traditional implementation of a system for field lights is as follows.

High-intensive and low-intensive lightings along approach paths, runways and taxiways are supplied from one or more supply points, so-called cabinets or stations situated in the airport field, usually two for a field with one runway. These supply points are fed with high voltage unregulated electricity which is transformed down to 380/320 V and the supply points contain regulator equipment, thyristor or transducer regulators or regulating transformers for converting the unregulated electricity into controlled, requlated electric power for supplying the light units, which takes place via several power supply loops. Supply takes place in two principally different ways, i.e. by series of parallel feed to the lightings. Each lifhting is provided with a transformer for retransforming the electricity to a suitable low voltage for supplying the lighting with power, in addition, the supply points also contain a supervisory system which monitors the status of the field lighting plant, e.g. such as to ensure that a sufficiently large number of light units function, that the intensity of the light units is correct etc. The supply points, i.e. the cabinets, communicate via a communication link, inter alia with the traffic control tower supervising and operating panel, from which the regulating and supervisory systems are controlled, and at which information from the systems is received. This communication takes place via separate wire pairs for each function, or with time multiplex transmission on wires or optical fibres.

The object of the present invention is to present a new method for supervising and controlling field lighting, and to provide a new field lighting plant, where each individual lighting is addressable and includes a communicating local regulator and a monitoring unit for supplying power to, and monitoring the lighting. Thus each lighting or subsystem of lightings can be controlled individually, irrespective of the sections into which the power cabling is divided.

This object is achieved with a method according to claim 1 and a plant according to claim 9.

Furthermore, the invention enables a presence indication system for detecting vehicle and aircraft movements on the ground to be integrated in the field lighting system implemented in accordance with the present invention.

Communication between the traffic control tower supervision and operating panel takes place via a central computer to a so-called concentrator and loop computer. The communication signals can be in the form of time multiplexed electrical or optical signals on signal cables or optical fibre cables.

A plurality of advantages are achieved by the present invention compared with the already known state of the airport lighting art.

In the implementation of a traditional field lighting system, the different power supply loops are fed via a regulator centrally connected to each loop for regulating the intensity of the lightings connected to the loop. For reasons of safety, the differrent lighting configurations such as approach lighting, runway edge lighting, glidepath beacons, threshold lighting and taxiway lighting must be fed by several loops in case there should be a regulator or cable fault. A large number of centrally placed regulators are therefore required for controlling the field lighting system, and these occupy large spaces which must often be specially built. With the present invention, on the other hand, each lighting is provided with a local regulator which is placed at the light fitting or in a so-called fitting well associated therewith. At the supply point there will only be a so-called concentrator, sling computer, contactor and modem. This results in less voluminous equipment, which gives savings in space and cost compared with the implementation carried out in a conventional way. In addition, the necessary redundance is obtained automatically with the method of implementation in accordance with the invention.

With a conventional method of implementation there is further required one or more lamp transformers at each lighting. These are heavy and take up considerable space. With the present invention, one or more of these transformers can be replaced by a small and light electronic unit on the fitting for intensity regulation and monitoring each individual lighting.

Since, in accordance with the present invention, each lighting can communicate and is addressable with the aid of its electronic unit, and is thus provided with local intelligence, a lighting with several

individual illumination points can control these separately in spite of the supply taking place merely over a single phase or a common cable. The necessary amount of power cable can thus be substantially reduced.

Field lighting plant for airports in accordance with the invention can advantageously be made up of certain modules, namely the lighting electronic unit (hereinafter denoted the AE unit), loop computer, concentrator and modem, where the concentrator and loop computer are realized with the same hardware but with different software, the plant being completed by a central computer and a supervising and operating unit in the traffic control tower (hereinafter denoted TWR). This simple, modular implementation method reduces the hardware costs for a given field lighting plant as well as design costs for a given lighting configuration. Since an ordinary-sized airport has several hundred lightings, the size of the AE unit manufacturing series will be considerable, which considerably reduces the manufacturing cost of each AE unit.

The modular method of implementation means that service and maintenance are facilitated. If an individual lighting does not light, this can either be due to the lamp or the corresponding AE unit failing, or both. In the great majority of cases, it is the lamp that fails, and therefore it is changed first. If a section coupled to a loop computer does not light, this can only be due to failing of the loop computer and modem, and this unit is then changed. Service and maintenance work will thus be extremely simplified, which is an advantage from the time, cost and personnel expects.

With conventionally implemented field lighting systems, there must be an ocular inspection of the field lighting at least once a day to determine which light units are defect. For airports with heavy traffic this must take place at night, since the runway system is not available for inspection during daytime. This results in increased costs. With the present invention this inspection is eliminated, since each lighting is individually monitored and a presentation of the status of each one can be obtained via the sling computer, concentrator and central computer, either on a display or printed out on a printer. In addition, monitoring can take place without the field lighting being lit up, since the AE unit only needs to drive a minimum amount of current through the lamp in order to decide whether it is failing or not. This method saves energy. Each AE unit can furthermore be implemented to enable measuring of the operating

time of the light source to which it is connected. Since the average life (illumination time) of the lamps in question is well known, this individual information as to lamp status, namely illumination time and functioning/failing enables planned maintenance of the field lighting plant, which gives better status of the plant and more effective utilization of maintenance personnel. The total illumination time of each light source is suitably continuosly registered at e.g. the central computer.

According to an advantageous embodiment of the plant in accordance with the invention, each lighting includes two separate light sources, the lighting configurations of which are identical. Only one light source is in service at a time, but should it fail the other light source is automatically connected, and information is sent that there is no reserve lamp for the lighting.

Since each lighting is addressable in accordance with the present invention, there is the possibility of guiding aircrafts, using parts of the field lighting system, for taxiing to and from runways, i.e., to arrange a so-called taxiway guidance system. This can be arranged by the lighting system along the central line of a taxiway being sectioned so that a given section is given a group address. This section can then either have its own operating button in a control tower panel where the section is lit when the appropriate button is pressed, or the central computer in the system can select a path with given input values for the taxiing path of the aircraft, taking into consideration any maintenance work on the taxiway, or to other aircraft movements etc. The decided path can either be lit up simultaneously in its entirety or successively in front of the aircraft. In existing plants this sectioning has been achieved by each section being provided with a separate power supply. With the present invention, the sectioning is performed, with the aid of the AE units' addresses, in the software, which drastically reduces the installation costs for a guidance system, and simplifies any future changes in the section configuration.

The invention can also be used for detecting vehicle and aircraft movements on the ground, i.e. it can form a so-called ground traffic detection system. In airports with heavy traffic, the collision risk between aircraft/aircraft and aircraft/vehicle is namely a great problem in poor visibility conditions. Since the inventive lighting system includes "intelligent" and addressable AE units at each point where there

is a lighting, every taxiway and runway can be divided into frequent identification blocks. This inventive implementation of the plant, supplemented with a presence detector allocated to each fitting the complete field lighting system or parts thereof enables detection and supervision of aircraft and vehicle movements along the rolling way system or parts thereof. The signals from the ground traffic detectors are taken up by the AE units and transmitted together with other lighting information via loop computer and concentrator to the central computer, which depicts the ground traffic on a display. The central computer, or a special supervisory computer, can give an alarm for situations where unpermitted ground traffic situations occur. This ground traffic detection system integrated with the field lighting system is very cost-effective compared with existing ground radar systems. The present invention moreover permits that only those parts of the rolling way system selectively chosen from the safety aspect are provided with ground traffic detection capacity, whereby further cost savings can be made.

In accordance with a further advantageous development of the invention, the guidance system is integrated with the ground traffic detection system such that the centre line lights included in the guidance system are lit up or extinguished or change lighting colour in front of and after the taxiing aircraft, respectively, lighting up and extinguishing the centre line lights taking place individually or in sections with the aid of control signals from the presence detection of the aircraft.

According to another embodiment of the plant, each lighting position where an AE unit is to be connected is provided with an unique address, which is automatically transferred to the AE unit when the unit is connected, such that this address is tied to its location and is not lost if an AE unit were to be changed.

An advantageous method of realizing an address which is not tied to the AE unit but to its position is to arrange a plurality of permanent magnets in the AE unit mounting such that these magnets have a unique combination of north and south pole orientation, giving the position in question an unique address which is automatically transferred to the AE unit by magnetic field-sensitive elements when the unit is connected. An eight bit address can be realized using eight magnets, for example.

According to a still further advantageous embodiment of the plant, and via the AE unit, the lightings are made for three-phase supply

enabling the supply to be dimensioned to cope with a phase failure up to a predetermined current or voltage level. Up to this level all lightings light with no change if there is a phase failure. The central computer can be programmed such as to increase the number of lightings which are extinguished with an increasing modulation in order that the maximum transmitted power for two phases is not exceeded.

Examples of the invention will now be described in more detail, with reference to the accompanying drawings, where Fig. 1 illustrates the two systems in use today for controlling field lighting at an airport, Fig. 2 illustrates the principle implementation of an embodiment of the plant in accordance with the invention, Fig. 3 illustrates the principle system implementation of an embodiment of the plant in accordance with the invention, Fig. 4 illustrates an embodiment of the lighting electronics in the inventive plant, Fig. 5 illustrates an example of the realization of a unique address for each fitting, Fig. 6 illustrates the principle of ground traffic detection in the inventive plant, Fig. 7 illustrates an embodiment of the plant in accordance with the invention for microwave-based ground traffic detection, Fig. 8 illustrates a system with stop lights having automatic re-illumination for controlling ground traffic, Fig. 9 is an idealized depiction of vehicle and aircraft ground movements and Fig. 10 illustrates a guidance system in a conventional construction and a system which may be realized with the plant in accordance with the invention.

Fig. 1 illustrates the two different systems used today for controlling the field lighting at an airport. The internationally most usual form is the so-called series system. The power supply line is here fed with a constant current which can be set at different levels. The lightings 20 on the field are connected via a so-called series transformer 50 in series with each other. Two or more such loops are required for supplying each lighting system such as runway edge lighting, approach lighting, glidepath beacons, centre line lighting, taxiing lighting etc. Since the lightings 20 are in series there is most often required high secondary voltage at the main transformer 51. The regulator 24 is connected on the primary side. In fig. 1 it is illustrated as a thyristor regulator 46, 48 but it can also be a transductor regulator or a regulating transformer.

The power supply system most usual in Sweden is the so-called parallel system. In this case the lightings 20 are connected in parallel

to each other via their individual transformers 21 along the power supply loop. Transducer regulators or regulator transformers are used here as well, apart from thyristor regulators 24, 46, 48. The control and monitoring equipment, (the equipment to the left of the dashed line in Fig. 1), is often placed in so-called cabinets or stations in the field for these systems. For a medium-sized airport there are usually about 10-15 such regulator units for supplying the different power supply loops included in the field lighting system.

Fig. 2 illustrates in principle the implementation of an embodiment of a plant in accordance with the invention. The power supply loop is here formed of the ordinary power supply, and connected to each lighting 20 there is a so-called lighting electronic unit 18, denoted AE.

Fig. 3 illustrates the principle system implementation of a plant according to an embodiment of the invention.

Field lighting installations (existing and future) are controlled and monitored from an operating panel in the airport control tower (TWR). In the invention, a so-called central computer 4 senses the status of the different functions of the operating panel and sends control signals via its control program to one or more so-called concentrators 14. These are most often placed in a so-called power control cabinet 22 at the power supply points for the field lighting. This communication between the central computer 4, most often placed in the apparatus room of the control tower, and the concentrator 14 may be by a time multiplexed signal on cable or optical fibre. Radio signalling can also be used. The concentrator 14 sends its control signals further to one or more loop computers 16. Via a modem communication each loop computer 16 looks after the AE units 18 which are connected to the associated power supply loop. One loop computer can at present communicate with a maximum of 127 AE units, with retention of the necessary rapidity in the system. Communication between the loop computer 16 and the respective AE units 18 along the loop can either take place with digital signals superposed on the power supply loop or via separate signal cable. The most advantageous embodiment appears to be communication via the power cables, no special signal cable thus being required.

Each AE unit 18 monitors the status of the lighting fitting 20 and sends this information to the loop computer 16 in question, for further transmission via the concentrator 14 to the central computer 4, which co-ordinates the information and gives an alarm when so required. As will be

seen from Fig. 3, the status of the plant can also be depicted on a screen 6 with associated keyboard 8 or a printer 10 in the so-called operational supervision centre. As is further apparent from Fig. 3, this embodiment of the plant in accordance with the invention, with supply to the lightings 20 via AE units 18, permits this new control and monitoring method to be mixed with the conventional technique using series of parallel supply by the power supply loops. The loop computer 16 thus provides a centrally placed regulator 24 with the necessary control signals (criterion values) and it also monitors the regulator 24 so that the right intensity is set and the right load connected to the loop. This possibility of combining conventional power supply methods with the new technique in accordance with the invention makes the system very flexible.

For meeting functional reliability requirements, the central computer 4 and the power control cabinets 22 can be doubled, as indicated in Fig. 3 by dashed lines. When the central computer 4, 4' and the power control cabinets 22, 22' are doubled, all the cables between the operating panel and the power control cabinets 22,22' are similarly doubled.

A monitoring unit 12, e.g. of the so-called watchdog type, is connected to both the central computers 4, 4' for monitoring the function of the plant.

Fig. 4 illustrates an embodiment of the AE unit in the plant in accordance with the invention. This comprises a modem 36 for receiving control signals which are either carried on separate signal cables or are digital signals superposed on the power cabling. The AE unit further includes a lamp control unit 35 with a microprocessor and associated interfaces 37 and power semiconductors 39 for regulating the power supply to the light sources 20. The microprocessor of the lamp control unit 35 also looks after monitoring of the operation so that if incorrect light intensity is set, or if a lamp 20 fails, the AE unit sends information on this to the loop computer 16, c.f. Fig. 3.

Power control in the AE unit can take place according to several different principle methods. Fig. 4 illustrates so-called primary switching, with which, while using high switching frequency, there is obtained extremely small lamp transformers and thereby a very compact construction. Ideally, the transformer decreases in size inversely proportional to the frequency. The frequency is determined here by the construction of the lamp control unit 35 and control can take place, e.g.

by pulse length modulation, i.e. the pulse length in the "on position" is greater for higher output effect, and for lower output effect this pulse length becomes shorter, the switching frequency being constant the whole time.

A voltage regulator 41 is illustrated in Fig. 4 for supplying the electronics. the fitting electronics also includes a rectifier bridge 43 and a filter 45 for preventing noise from the fittings and electronics to propagate to the network.

By each lighting having its individual regulator, at least certain lightings can advantageously be fitted with battery backup, so that for voltage failure the lamp in the lighting continues to light with predetermined intensity.

Each AE unit has its unique address, as mentioned above. There is thus obtained a possibility of individual control and monitoring of each lighting 20 or section of lightings. Fig. 5 illustrates an advantageous method of achieving this. Permanently situated on the lighting there is a magnetic strip 1 containing the necessary number of permanent magnets 3. The magnets 3 are made as reversible magnet plugs to enable pole reversing. The AE unit contains magnetosensitive elements 2, for sensing the orientation of the north and south poles of the magnets, this orientation enabling a binary address code to be obtained, at 4 in Fig. 5. When the AE unit is positioned it automatically obtains its address, which is permanently associated with the location. This means that each AE unit can be used anywhere in the field lighting system, as far as addressing is concerned, which is advantageous from the point of view of service and maintenance. The embodiment illustrated in Fig. 5 shows how the magnetic field 5 connects the address code from the permanently installed address code transmitter B to an address code decoder A in the lighting electronic unit without galvanic contacts, a signal converter and address transmission unit 6 being connected to the decoder.

It is obviously possible to implement this memory so that the input address is also retained when there is no current, the input taking place with the aid of a special command to start with.

With the technique in accordance with the invention for controlling and monitoring the field lighting using addressable local regulators there is obtained the field system divided into unique addressing blocks a_i, as is illustrated in Fig. 6. By providing the field system with the required number of presence detectors 72, c.f. Fig. 4, a system for

detecting vehicle and aircraft ground traffic can be achieved, integrated with the field lighting system. In such a case the presence detector can be placed on a lighting fitting, as illustrated in Fig. 7. Since each fitting has a unique address to which the presence detector signal is correlated, vehicle and aircraft movements on the field can be supervised with the aid of this procedure.

In the illustrated embodiment, the presence detector 72 comprises a microwave based detector. The microwave signals are transmitted and received via an antenna unit 71 and are evaluated at 74. However, the detector can be based on other physical measuring principles using such as supersonics, infrared rays, eddy current etc.

In order to control the ground traffic, above all in airports with heavy traffic, stop lights are required at the entrances to runways, and also at crossings between taxiways. Such an arrangement is illustrated in Fig. 8, the stoplights 11 are usually sunk lightings arranged across the taxiway 80, where it is suitable to stop the traffic. The stoplights 11 comprise a line of at least 5 light units sunk into the taxiway and providing directed, steady red lights solely for the traffic which is to be stopped. Light ramps included in the stop light system must be enabled for separate operation in the control tower, and the installation of the stop lights should be carried out so that not all light units in such a ramp are extinguished at the same time for failure in the supply system.

The stop lights 11 are controlled such that when an aircraft 82 approaches an illuminated ramp of stop lights, the pilot stops the aircraft and calls the control tower to obtain permission to pass the stoplights. The flying controller gives a clearance sign for passage by extinguishing the stop lights. When the aircraft 82 has passed the lights, they shall be illuminated once again with red light as soon as possible to prevent further aircrafts from unintentionally crossing them. This re-illumination takes place either manually or automatically. For configurating a stop light ramp with automatic re-illumination, and using the technique known up to now, there are required at least two centrally placed current regulators in order to obtain the separate operation required according to the above, and also to obtain the necessary redundance.

In apparatus of this kind known up to now, the automatic re-illumination is controlled by a separate traffic signal system which, with separate current supply and with separate control signal cables, is

connected to the regulator units for the lighting in question. This is an expensive way of controlling and automatically re-illuminating only five light units, for example.

A configuration in accordance with the present invention is illustrated in Fig. 8. Each lighting in the stop lights 11 is provided with an electronic unit AE, which is controlled via the power cables from the loop computer/concentrator 13, 14. Supply can take place as illustrated in the figure, e.g. it can be three-phase supply to obtain great redundance in the supply. The same power supply which is used, e.g. for surrounding illuminated signs, can be used for supplying the stop lights and thus considerably reducing cable costs. A presence detection system is integrated into the configuration for obtaining the automatic re-illumination. In fig. 8 there is illustrated a microwave-based presence detector 12 with a transmitter ND/S and a receiver ND/M. A fitting electronics unit 17 is connected to the receiver for looking after the signal from the receiver. The signal from the receiver is sent on the cable 18 to the associated loop computer 13, which in turn sends the re-illumination signal to the fitting electronic units of the stop lights. Also schematically illustrated in the figure are the necessary modem 15, way edge lighting 16, a power point 19 and signal cable 21 to an operating and display panel 10 in the control tower.

The described configuration for controlling and automatically re-illuminating the stop lights 11 for aircraft at an airport is substantially cheaper than the configuration according to previously known technique, with regard to hardware cost and cable cost. In addition there is automatically obtained great redundance, which is important from the safety aspect, a possibility of being able to regulate the intensity of the stop lights being obtained as well.

The system permits vehicle and aircraft movements to be depicted on a monitor in the control tower or at another desired place, see Fig. 9. The described method of detecting ground traffic is very cost effective compared with today's ground radar systems. Such systems also have the disadvantage that in heavy rain and snowfall they cause high background noise, thus causing difficulties in effective supervision. Another advantage with the solution in accordance with this invention is that if the field movement supervision is only desired or required for a small part of the runway system, this can be advantageously achieved.

At airports with the most heavy traffic in the world today, so-called guidance systems have been built up to guide aircraft when taxiing to and from runways, see Fig. 10. The lower part of the figure illustrates how such a system is built up today. This is done by the power supply to the lightings in question being sectioned so that each section can be lit up and extinguished individually. A large amount of cable is required for this, as well as many centrally placed regulators. With the present invention having addressable regulators the sectioning is done in the software. Different sections of lightings can thus be connected to the same power supply cable, and merely by defining what lighting addresses are associated with a certain section the section in question can be lit up and extinguished individually. This configuration results in large cost savings, see the upper part of Fig. 10.

Claims

1. Method of supervising and controlling field lighting at an airport, c h a r a c t e r i z e d in that each lighting has a regulator with associated monitoring unit for power supply to and monitoring of said lighting, which is addressed individually for controlling the light intensity of the lighting and for receiving information as to the operational status of the lighting.

2. Method as claimed in claim 1, communication between a traffic control tower and the lightings taking place via a so-called loop computer and modem, c h a r a c t e r i z e d in that communication between the loop computer and lightings is expedited over existing power cables, and superposed on the existing power supply.

3. Method as claimed in claim 1, communication between a traffic control tower and the lightings taking place via a so-called loop computer and modem, c h a r a c t e r i z e d in that communication between loop computer and lightings is expedited via a special signal cable.

4. Method as claimed in either of claims 2 or 3, c h a r a c t e r i z e d in that the lightings along one or more power supply loops are addressed from a loop computer individually or in groups.

5. Method as claimed in any one of claims 1-4, c h a r a c t e r i z e d in that the central line lighting on a taxiway is lit up successively, individually or sectionally, in front of a taxiing aircraft for indicating the route of the aircraft when it is taxiing home or out, the necessary electric sectioning being determined in the software of a central computer via the addresses of the lighting electronic unit, and lighting being controlled by the taxiing route determined in the central computer.

6. Method as claimed in claim 5, c h a r a c t e r i z e d in that the extent of lighting up, extinguishing or changing colour of the light is controlled via a presence detecting system.

7. Method as claimed in any one of claims 1-6, c h a r a c t e r i z e d in that said output effect of each lighting for a given intensity level is changed by reprogramming via a centrally placed computer using the lighting electronics unit in situ.

8. Method as claimed in any one of claims 1-7, c h a r a c t e r i z e d in that the total illumination time of each light source is automatically and individually registered.

9. Plant for supervising and controlling field lighting at an airport, c h a r a c t e r i z e d in that each lighting is provided with an electronic unit controlling a regulator, monitoring unit and modem for power supply to the light source of the lighting, and for monitoring the operation of the lighting, each lighting being individually addressable from a control central for the airport.

10. Plant as claimed in claim 9, c h a r a c t e r i z e d in that a selected plurality of the electronic units of the lightings are each allotted a presence detector for forming a ground traffic detection system for detecting the ground movements of aircraft and vehicles, said detector including transducers based on supersonics, optics, magnetism, eddy currents, or microwaves.

11. Plant as claimed in claim 9 or 10, c h a r a c t e r i z e d in that each lighting electronic unit includes a unique address block, permanently mounted on the lighting, or its associated lighting well, such that when said unit is put in place the lighting is automatically given its unique address.

12. Plant as claimed in claim 11, c h a r a c t e r i z e d in that the address block includes permanent magnets, the north and south pole orientation of which gives a unique digital address, the lighting electronic unit containing magnetism-sensitive elements for sensing the north and south pole orientation of the magnets.

13. Plant as claimed in claim 10, c h a r a c t e r i z e d in that at least certain lightings are arranged to form so-called stop lights, each lighting of these stoplights including an individual electronic unit, and in that a presence detection system connected to said stop lights is arranged for automatically giving a re-illumination signal to the lightings of the stop lights as a reply to the passage of an aircraft or other vehicle past the stop lights.

14. Plant as claimed in any one of claims 9-13, c h a r a c t e r i z e d in that a given number of lightings are provided with battery backup, so that should there be a voltage failure the light intensity of the lamp is regulated to a previously determined value.

15. Plant as claimed in any one of claims 9-14, c h a r a c t e r i z e d in that the power supply to the lighting electronic unit is three-phase connected, and disposed such that should a phase fail, all the light units continue to light up with unaltered intensity unless the light intensity exceeds a predetermined value, at which a predetermined number of lightings are adapted such as to be extinguished.

16. Plant as claimed in any one of claims 9-15, c h a r a c t e r i z e d in that each lighting includes two separate light sources, the light configurations of these sources being identical, it only being intended that one light source is connected at a time, and in that the lighting electronic unit is adapted such that for a failure of one light source it automatically connects the other and gives an alarm for the failed light source.

Fig. 1

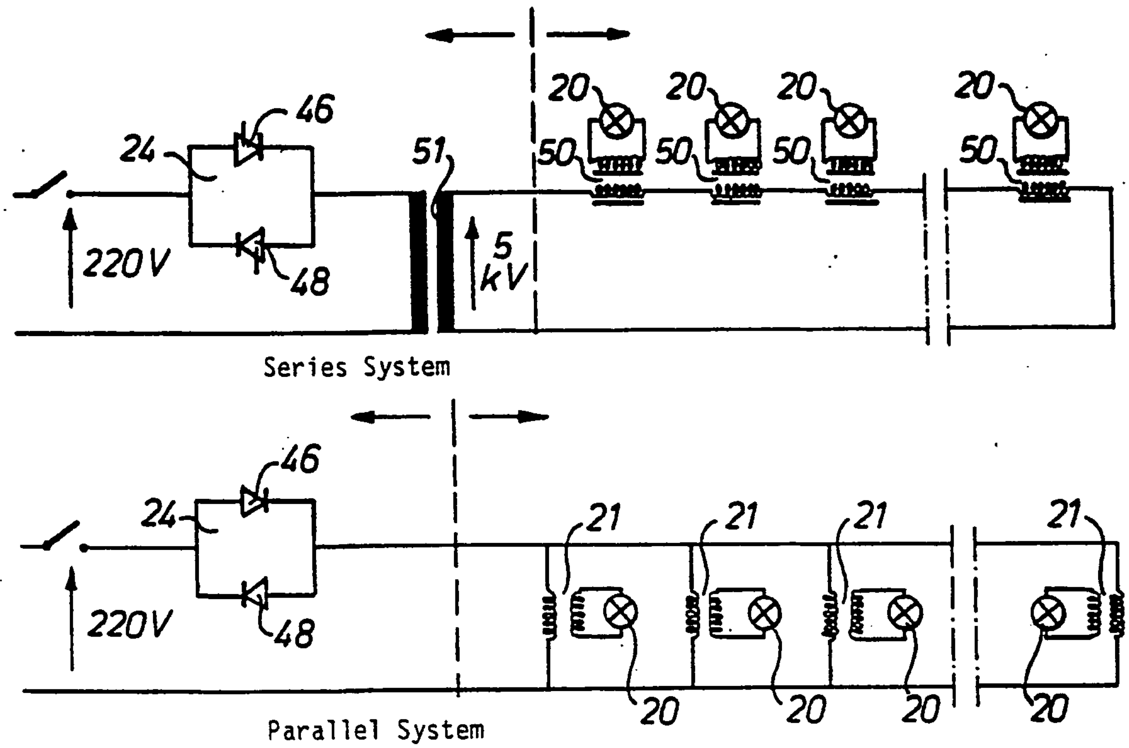

46
24
51
20
50
220V
48
5
kV
Series System
46
24
21
220V
48
20
Parallel System

Fig. 2

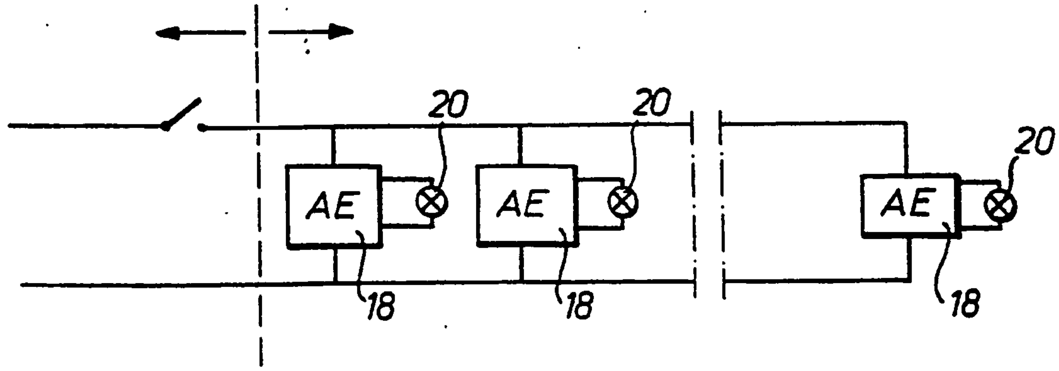

20
AE
18

Fig. 3

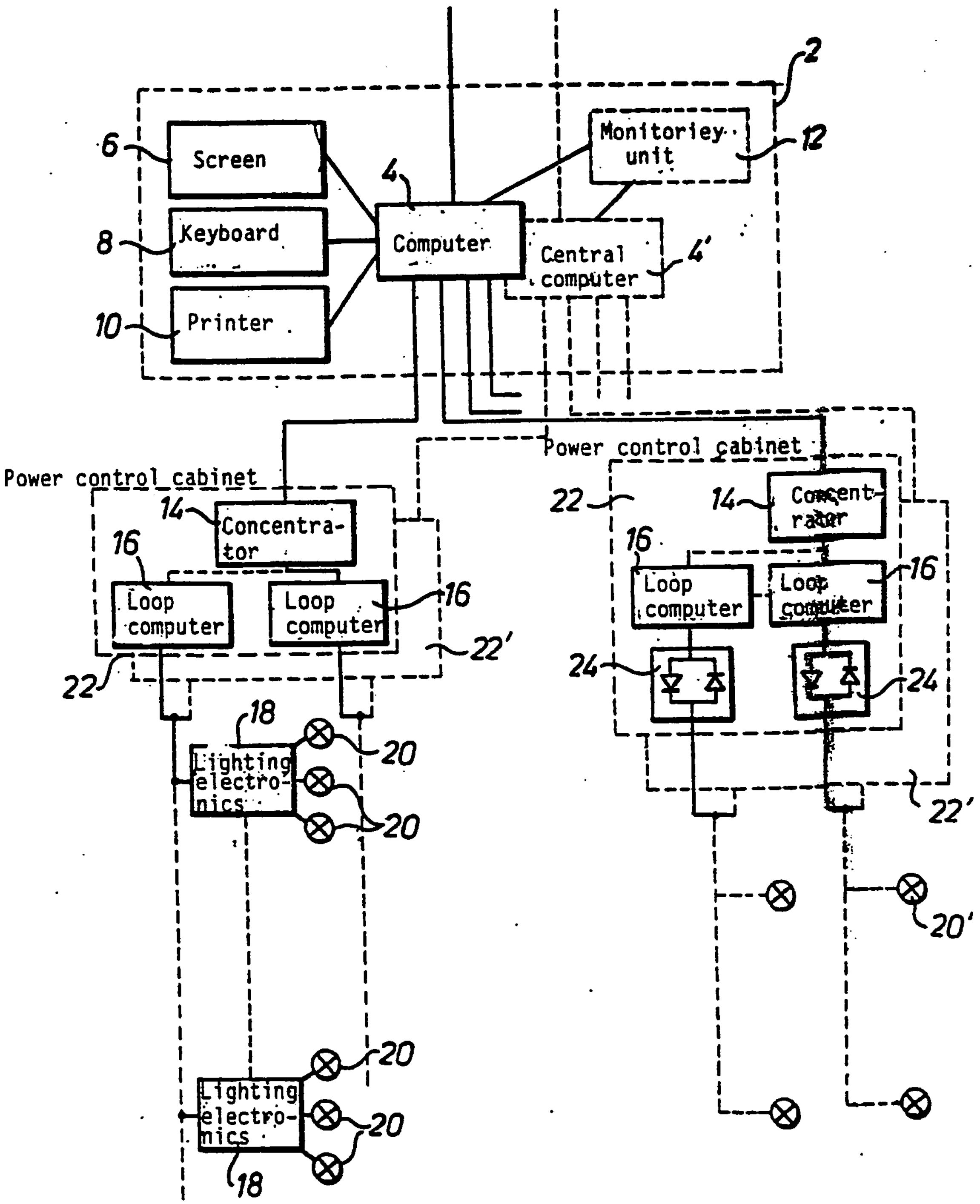

Control panel
2
Monitoriey unit
12
6
Screen
4
8
Keyboard
Computer
Central computer
4'
10
Printer
Power control cabinet
Power control cabinet
22
14
Concentrator
14
Concentrator
16
Loop computer
Loop computer
16
16
Loop computer
Loop computer
16
22'
24
24
22
18
Lighting electronics
20
20
22'
20'
20
Lighting electronics
20
18

Fig. 4

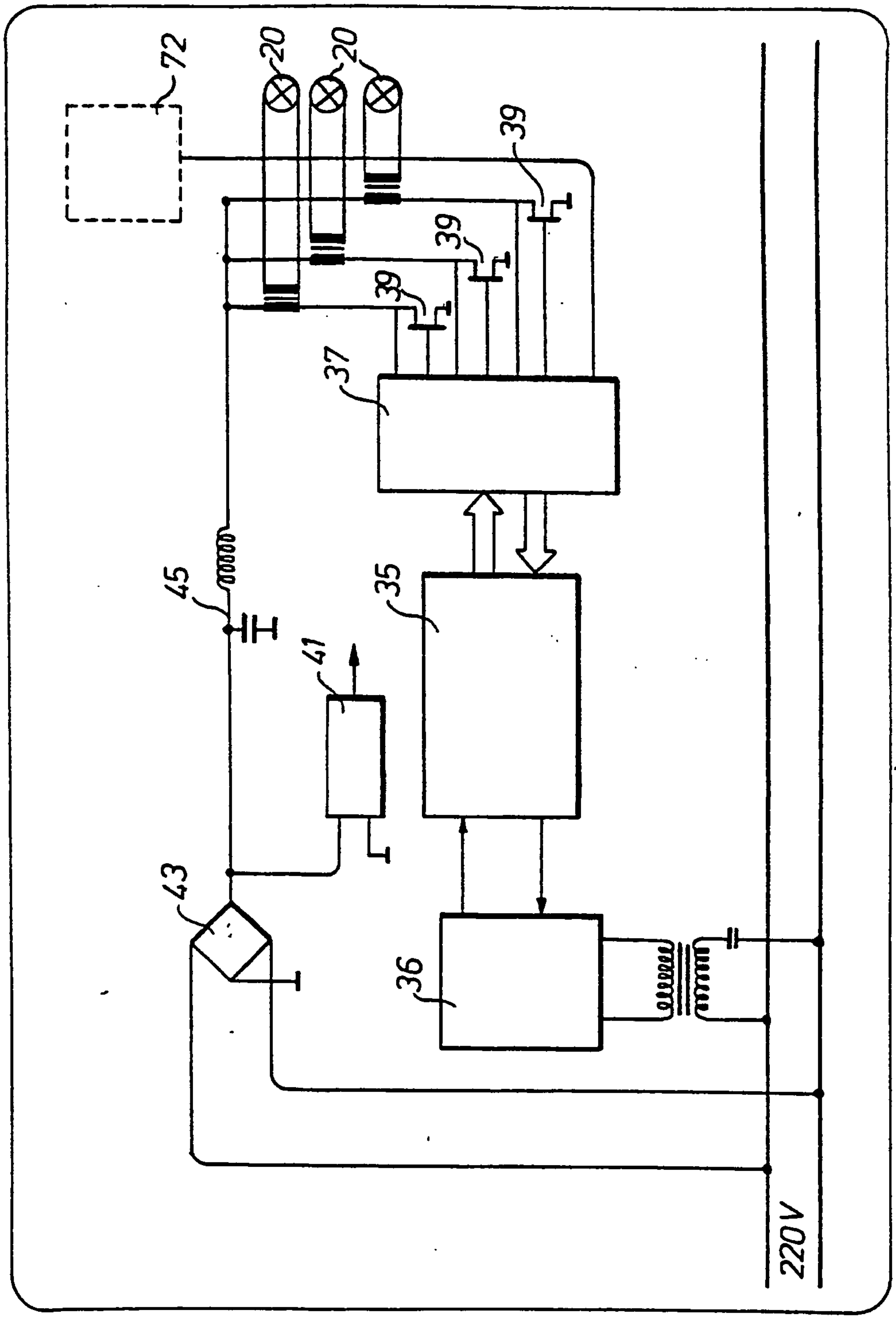


Fig. 5

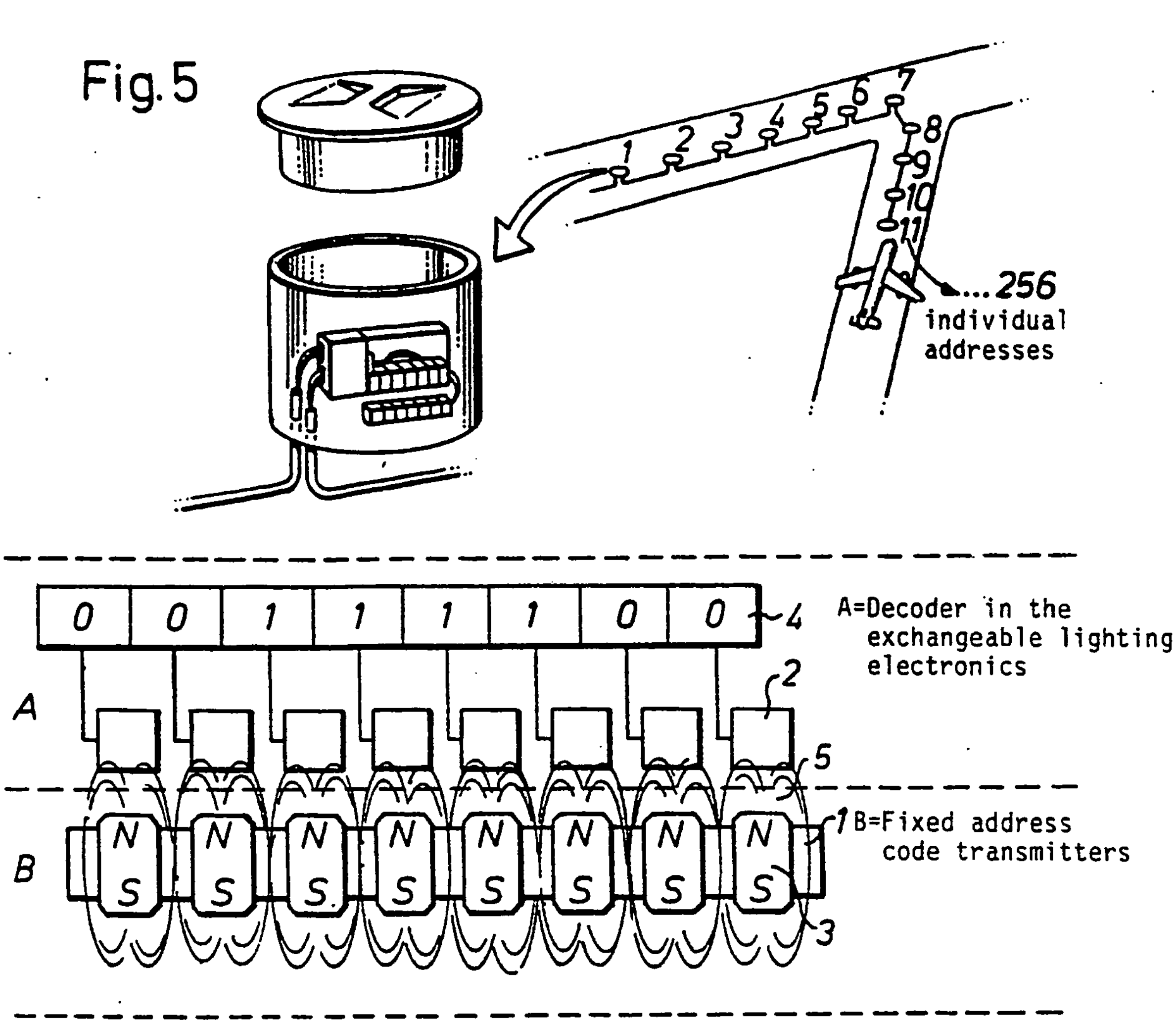
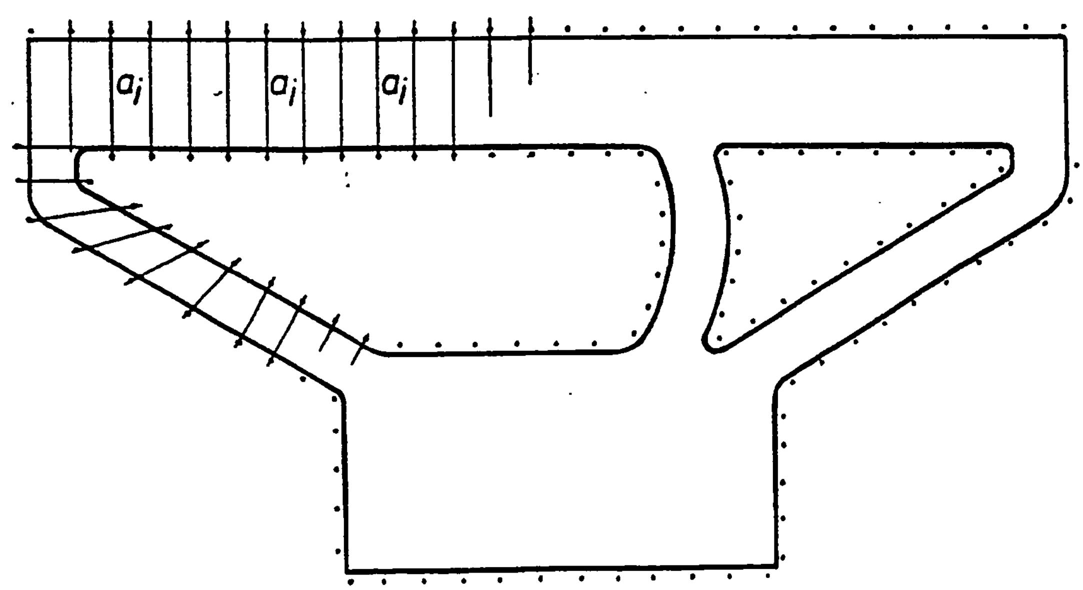

1
2
3
4
5
6
7
8
9
10
11
...256
individual
addresses
0 0 1 1 1 1 0 0
4
A=Decoder in the
exchangeable lighting
electronics
2
A
5
N
S
B
1
B=Fixed address
code transmitters
3

Fig. 6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a_i
a_i

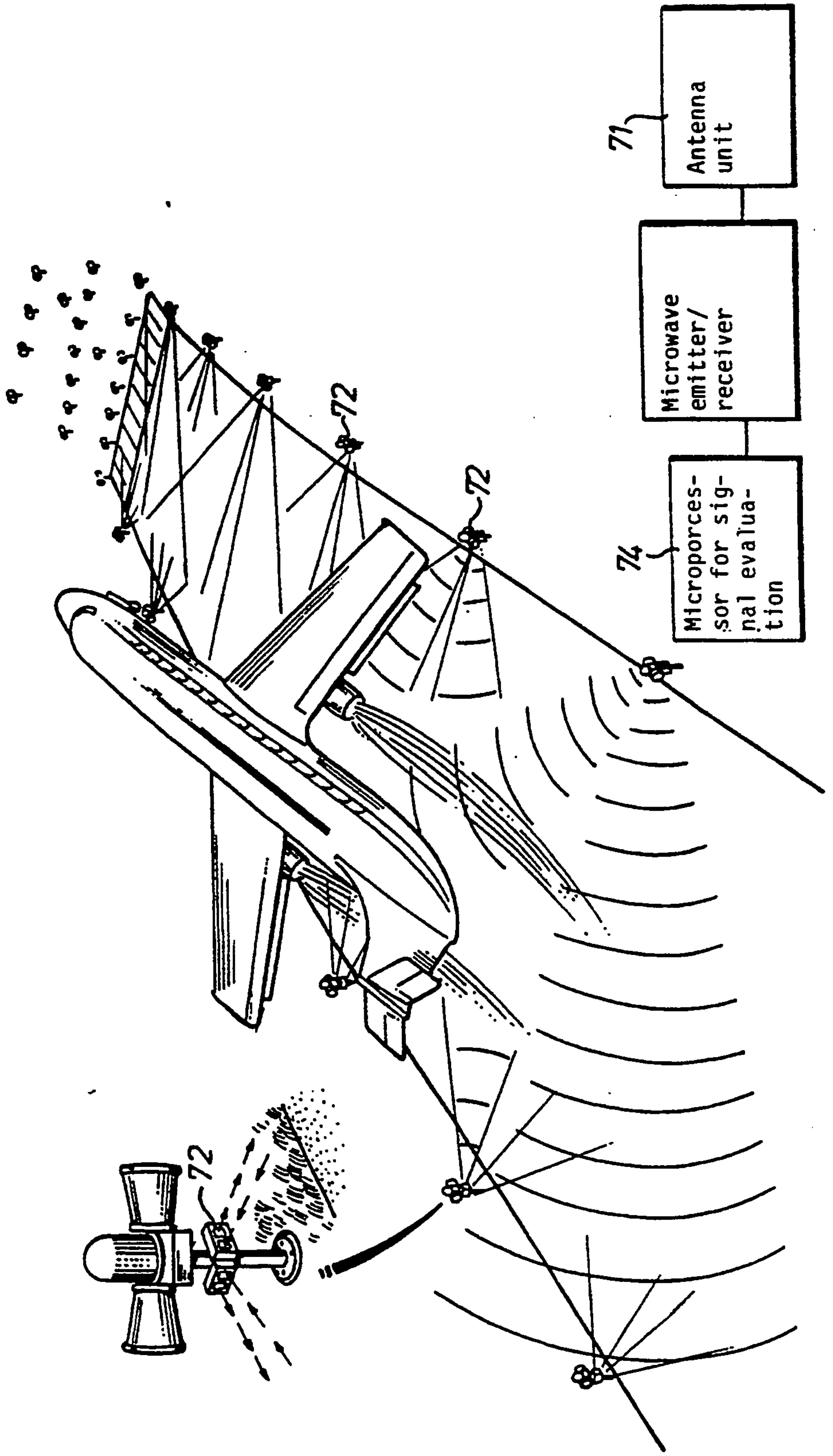

71
Antenna unit
Microwave emitter/ receiver
74
Microporces- sor for sig- nal evalua- tion
72
72
72

Fig. 7

Fig.8

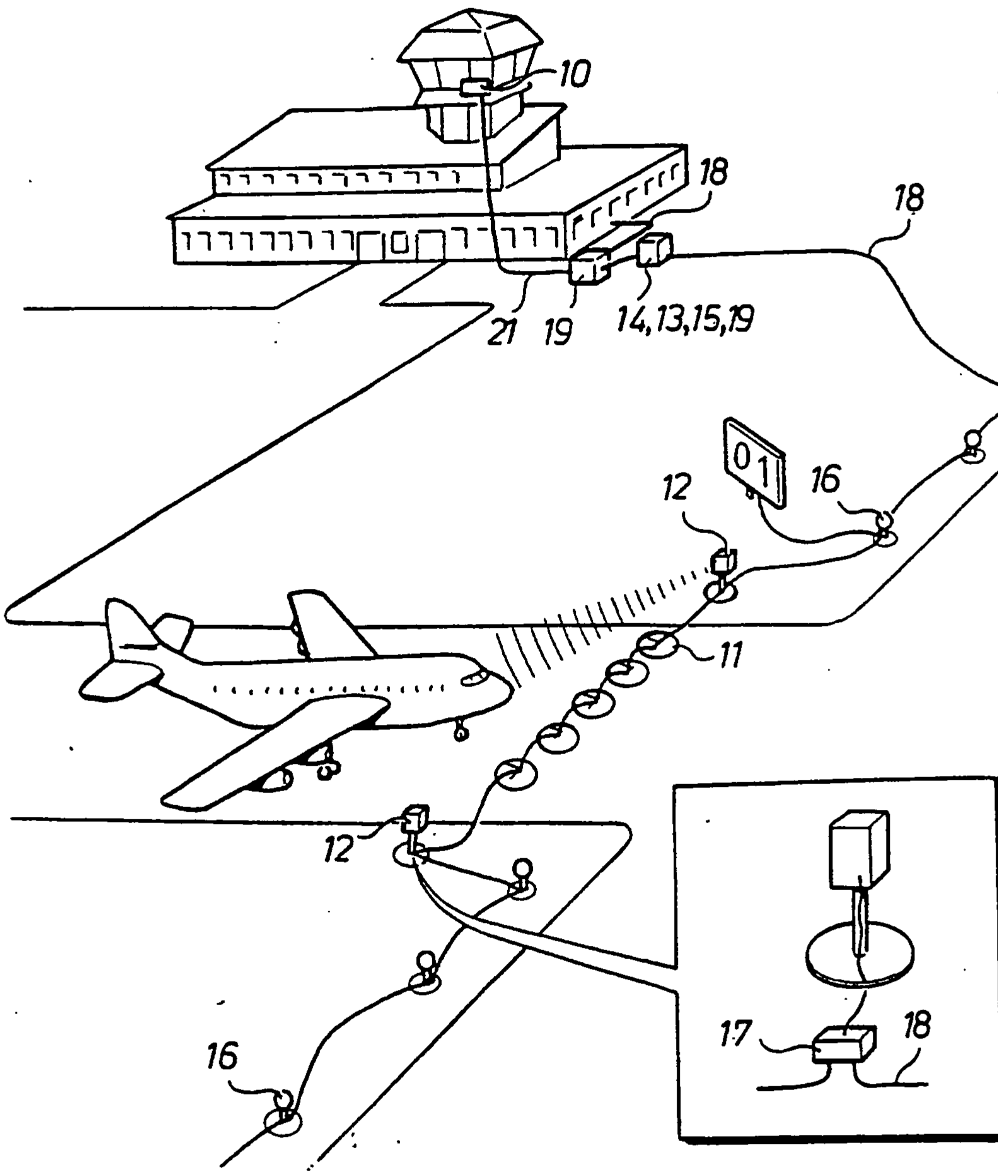


Fig. 9

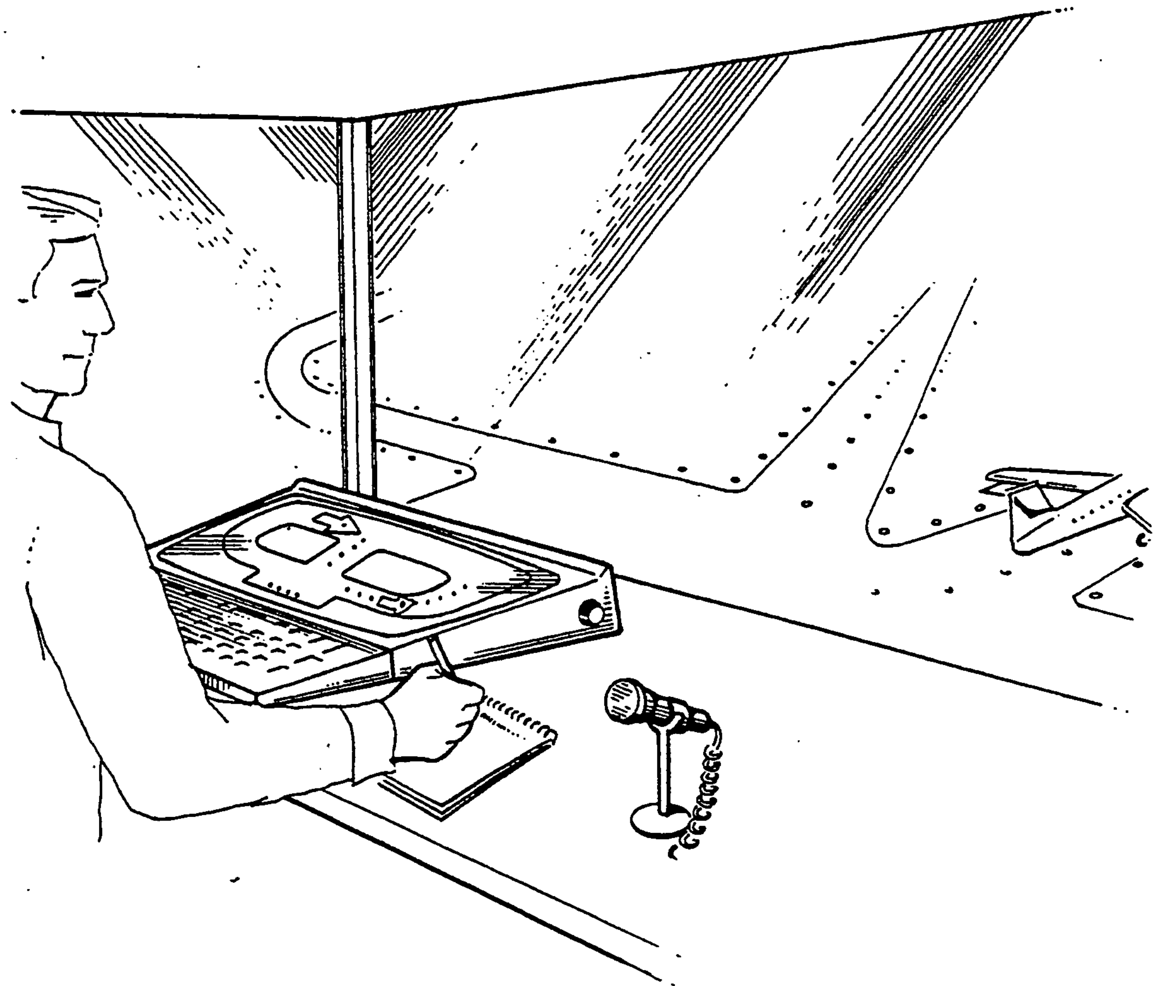
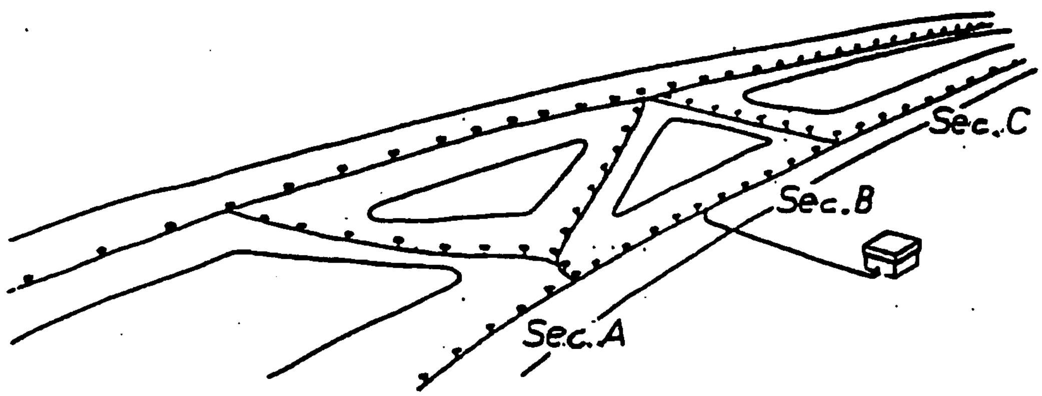
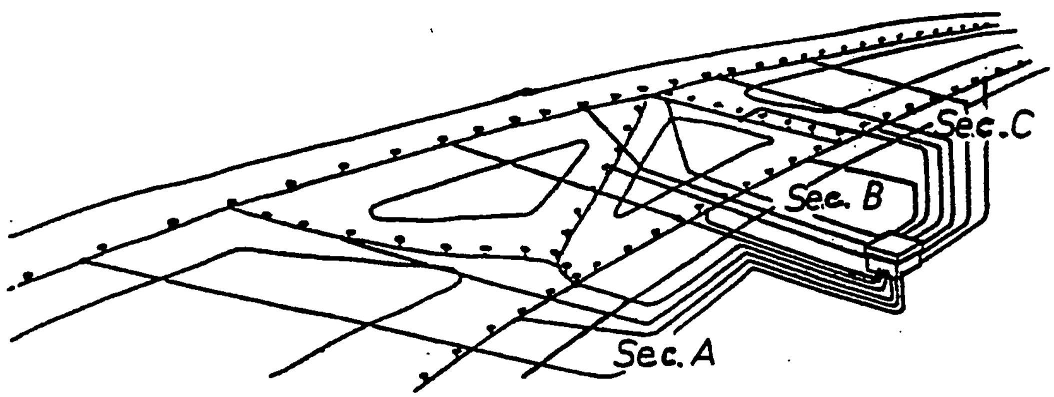


Fig. 10





INTERNATIONAL SEARCH REPORT

International Application No PCT/SE 89/00546

I. CLASSIFICATION OF SUBJECT MATTER (if several classification symbols apply, indicate all) [6]

According to International Patent Classification (IPC) or to both National Classification and IPC

IPC4: G 08 G 5/00, H 05 B 37/00

II. FIELDS SEARCHED

Minimum Documentation Searched [7]

Classification System	Classification Symbols
IPC4	B 64 F, F 21 P, G 05 D, G 08 G, H 05 B

Documentation Searched other than Minimum Documentation to the Extent that such Documents are Included in the Fields Searched [8]

SE,DK,FI,NO classes as above

III. DOCUMENTS CONSIDERED TO BE RELEVANT [9]

Category *	Citation of Document, [11] with indication, where appropriate, of the relevant passages [12]	Relevant to Claim No. [13]
Y	US, A, 4388567 (K. YAMAZAK ET AL) 6 June 1983, see the whole document --	1-7,9, 10,14, 16
Y	US, A, 4095139 (A.P. SYMONDS ET AL) 13 June 1978, see abstract --	1-7,9, 10,14,
Y	EP, A1, 0060068 (VARI-LITE) 15 September 1982, see abstract --	1-7,9, 10,14,
Y	EP, A1, 0069470 (PITTWAY CORPORATION) 12 January 1983, see abstract --	1-7,9, 10,14,
Y	GB, A, 2174852 (TANN ELECTRONICS LTD) 12 November 1986, see the whole document --	1-7,9, 10,14, 16

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IV. CERTIFICATION

Date of the Actual Completion of the International Search	Date of Mailing of this International Search Report
14th December 1989	1989 -12- 27
International Searching Authority	**Signature of Authorized Officer**
SWEDISH PATENT OFFICE	Bertil Nordenberg

Form PCT/ISA/210 (second sheet) (January 1985)

International Application No. PCT/SE 89/00546

III. DOCUMENTS CONSIDERED TO BE RELEVANT (CONTINUED FROM THE SECOND SHEET)		
Category *	Citation of Document, with indication, where appropriate, of the relevant passages	Relevant to Claim No
Y	US, A, 3122721 (Y.J. LIU ET AL) 22 May 1964, see the whole document --	1-7,9, 10,14,
Y	US, A, 4590471 (C.S. PIEROWAY) 20 May 1986, see the whole document --	5
Y	GB, A, 2155226 (V.M. ARANZANA) 18 September 1985, see the whole document --	6,10
Y	US, A, 4481516 (P.E. MICHELOTTI) 6 November 1984, see the whole document --	6,10
Y	US, A, 3801794 (R.E. MAUCH ET AL) 2 April 1974, see the whole document --	14
Y	DE, A1, 3703830 (LICENTIA PATENT-VERWALTUNGS-GMBH) 18 August 1988, see the whole document --	16
A	US, A, 4313063 (J.I. MCHERRON) 26 January 1982, see the whole document --	1,9
A	US, A, 4449073 (M.A. MONGOVEN ET AL) 15 May 1984, see the whole document --	1,9
A	DE, A1, 3635682 (BBC BROWN BOVERI AG) 28 April 1988, see the whole document --	1,9
A	US, A, 3771120 (R.P. BONAZOLI ET AL) 6 November 1973, see the whole document --	1,9
A	US, A, 3531765 (W.O. CHRISTIANSON ET AL) 29 September 1970, see the whole document -----	1,9

ANNEX TO THE INTERNATIONAL SEARCH REPORT
ON INTERNATIONAL PATENT APPLICATION NO. PCT/SE 89/00546

This annex lists the patent family members relating to the patent documents cited in the above-mentioned international search report.

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US-A- 4388567	06/06/83	GB-A-B- 2070830	09/09/81
		JP-A- 56118295	17/09/81
US-A- 4095139	13/06/78	NONE	
EP-A1- 0060068	15/09/82	JP-A- 57157491	29/09/82
		AU-D- 79646/82	09/09/82
		US-A- 4392187	05/07/83
		CA-A- 1181795	29/01/85
		EP-A-B- 0140994	15/05/85
		JP-A- 60143502	29/07/85
		AU-A- 546433	29/08/85
		JP-A- 61173402	05/08/86
EP-A1- 0069470	12/01/83	US-A- 4418333	29/11/83
GB-A- 2174852	12/11/86	NONE	
US-A- 3122721	22/05/64	NONE	
US-A- 4590471	20/05/86	NONE	
GB-A- 2155226	18/09/85	FR-A-B- 2560702	06/09/85
US-A- 4481516	06/11/84	NONE	
US-A- 3801794	02/04/74	NONE	
DE-A1- 3703830	18/08/88	NONE	
US-A- 4313963	26/01/82	NONE	
US-A- 4449073	15/05/84	NONE	
DE-A1- 3635682	28/04/88	NONE	
US-A- 3771120	06/11/73	NONE	
US-A- 3531765	29/09/70	NONE	

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INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

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(74) Agent: KANGASMÄKI, Reijo; Finnish Patent Consulting FPC, Hermiankatu 14, FIN-33720 Tampere (FI).

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Published
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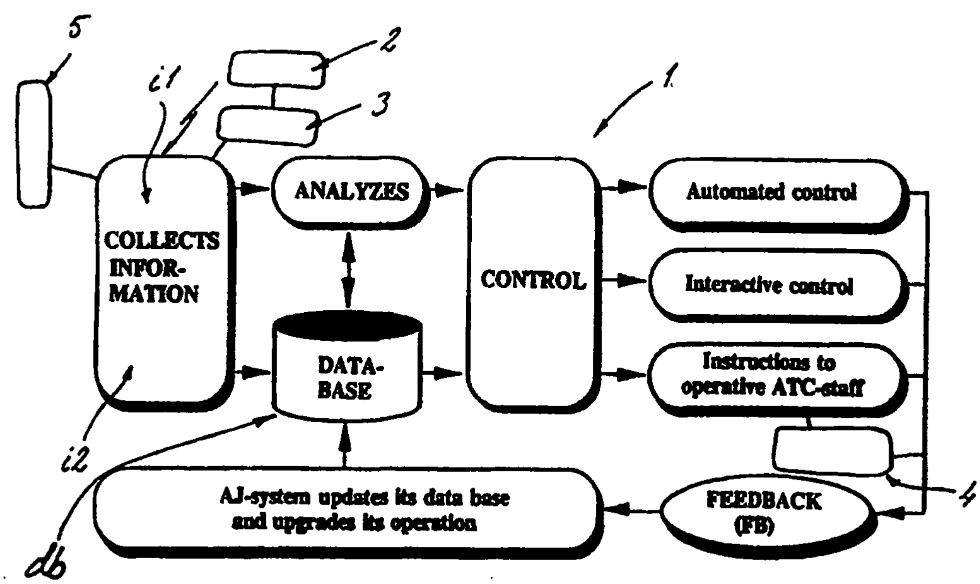
(54) Title: METHOD AND CONTROL SYSTEM FOR OPERATIVE TRAFFIC



(57) Abstract

The invention relates to a method for operative traffic, said traffic, such as operative ground traffic associated with air traffic, being controlled by means of a real-time and preferably so-called self-learning expert system (1), at least substantially all operative units, such as aircraft, field, maintenance, and upkeep equipment, vehicles or the like, as well as preferably also persons and groups of persons, present in an operative traffic area, being at least in an information transmitting communication therewith at least for the identification and substantially continuous positioning of the latter. The invention relates also to a control system applying the method.

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Method and control system for operative traffic

A method for operative traffic, said operative traffic, especially operative ground traffic associated with air traffic, being controlled by means of a real-time and automated data processing unit, at least some of the operative units, such as aircraft, field, maintenance, and upkeep equipment, vehicles or the like, present in an operative traffic area, being at least in an information transmitting communication therewith at least for the identification and positioning of the latter.

It is possible to apply a method of the invention in a wide variety of applications, e.g. for safely controlling operative traffic occurring on the ground, in water and/or in the air. One of the key applications for a method of the invention is the control of operative ground traffic associated especially with air traffic.

It is prior known that the ground traffic, especially one associated with air traffic, is run by using quite traditional methods and arrangements, each airport being always provided with an air traffic control tower, which is the base for controlling all airport operations involving both ground and air traffic activities by using conventional radar and monitor systems. However, the traditional control methods are largely based on visual monitoring performed by air traffic controllers, whereby, especially in adverse weather conditions, such as in fog, snowfall, or the like, the conditions may cause major setbacks and interruptions for air traffic. A principal reason for this is that it is not possible in all circumstances to visually make sure in a sufficiently reliable fashion e.g. the condition of a required runway door the equipment possibly present in such runway.

Therefore, e.g. after a snowplowing operation, it is generally necessary to wait at least an hour before it is possible to re-commission a runway to its primary applications. Snowy conditions are particularly inconvenient for traditional air traffic control methods since, as a result of sufficiently long runway standstill required as a safety precaution, there is time for fresh snow to gather thereon prior to the next commissioning of the runway, and this necessitates another pawing operation very shortly, leading to a continuing delay in air traffic as snowfall continues.

In addition, the traditional control system is not capable of controlling and guiding e.g. a landed aircraft to a terminal best suited for a given situation but, in principle, it is necessary to always stick with operating plans decided a long time before. Thus, e.g. occasional malfunctions, equipment breakdowns etc. often cause lengthy downtimes, resulting in a confusion in terms of preplanned timetables and arrangements. Furthermore, so-called "last-minute tune-ups" in traditional inflexible control systems frequently cause danger situations since, with manual arrangements, it is not possible to account for a sufficient number of factors even in minor changes of operating plan.

The prior art is described in US Patent 4,827,418, relating to an expert system which relies on so-called artificially intelligence based data processing for controlling the altitude and heading of especially airborne aircraft in order to avoid collisions. Such solutions make use particularly of LISP-programming or the like which, however, from the viewpoint of a person skilled in the art, does not have any significant equivalence to the processing solutions of the present invention. Thus, the system disclosed in

the cited patent is indeed primarily intended for air traffic control, which can also be used as an air control simulator. Moreover, in the cited solution, e.g. the positioning is carried out conventionally by means of a radar. It should further be noted that the mere LISP-programming represents quite traditional processing in terms of technology and, hence, the (at present virtually "out-of-use") LISP-programming is not even close to being sufficiently powerful in terms of solving problems equivalent to those addressed by the present invention.

On the other hand, unlike both the above-cited and the present invention, the reference publication EP 613,109 encompasses infrared-radiation based transmitters and receivers for the identification and positioning of aircraft in a ground traffic area. In the cited solution, the positioning is largely based on monitoring the field temperature levels, whereby sensors mounted on the field detect a new aircraft on the basis of an increase in temperature. Thereafter, the heading of this particular aircraft is determined as soon as some other heat identification unit has detected the elevated temperature caused by this aeroplane. Then, it is possible to determine mathematically the heading/acceleration/speed etc. of the aircraft, e.g. by the application of vector mathematics or the like.

From the viewpoint of a person skilled in the art, the cited solution is also essentially different from the present invention since, first of all, it is based on IR radiation. On the other hand, the positioning of aircraft as well represents quite traditional technology, especially in light of the present invention, nor does it function with reliability that would be even nearly equal to that of the present invention. Neither is the cited type of arrangement by

any means such that it could be utilised, at least not with a sufficient reliability, for monitoring the movements of persons/groups of persons working within a ground traffic area.

Thus, the cited solution is only capable of performing a fraction of what can be done with the present invention. Moreover, especially the use of IR radiation in this connection is unfavourable particularly for the following reasons:
- restricted in terms of its range/power
- necessitates a physical contact
- a limited number of channels
- out-of-date technology
- few practical applications, and even those in not absolutely crucial circumstances.

Hence, what the cited solution has in common with the present invention is primarily that it is intended for monitoring the position of aircraft or the like currently within a ground traffic area for avoiding collisions or the like by means of computer-assisted processing.

An object of a method of the invention is to provide a decisive improvement in terms of the above problems and hence to raise substantially the available prior art. In order to achieve this object, a method of the invention is principally characterized in that an expert system is informed about each unit on commission within an operative traffic area, preferably including also persons or groups of persons within the operative traffic area, by means of a radio-frequency operated transmitter system as well as by means of an antenna system enabling a substantially continuous-action positioning, the operative traffic being monitored and controlled by means of a comprehensive expert system, preferably making use of

so-called soft computing technology, such as a sum logic, a neural network, a neuro¬sum logic, chaos theory, genetic algorithms and/or the like for enabling its adaptive or self-learning operation.

The most important benefits gained by a method of the invention include simplicity, reliability in operation, and a remarkable improvement in the safety of operative traffic, the method making it possible to safely control for example all operative traffic associated with aviation while eliminating safety hazards and risk factors in the ground traffic within an airfield perimeter all the way from the landing of an aircraft to its take-off. A method of the invention also improves the speed and reliability of decision-making especially in abnormal situations, the method making it possible to eliminate unnecessary operation stoppages as well as congestions. Thus, a method of the invention provides a substantial improvement in the flexibility of especially ground and air traffic control, thereby producing a significant increase in the capacity of airfield traffic and in the economy of the entire airport operation. One further advantage gained especially by so¬called soft computing technology over the prior art-technology is that, first of all, e.g. the neuro-sum logic provides a system which is distinctly more inexpensive, speedier, and simpler than those described above and which requires significantly fewer rules. In addition, the deduction-making is significantly speedier, with possibly more than 1000-fold differences in favour of the presentinvention.

The non-independent claims directed to a method disclose preferred applications for a method of the invention.

The invention relates also to a control system operating in accordance with the method. The control system is defined in more detail in the preamble of an independent claim directed thereto. The principal characterizing features of the control system are set forth in the characterizing clause of the same claim.

When correctly implemented, the control system of the invention is trouble-free, operates in real time, and self-learning, in addition to which it can be coupled, e.g. in the afore-mentioned aviation, e.g. interactively with ground radar, surveillance, or e.g. meteorological systems or the like. Since it is also possible to connect the operative staff to an integral, intelligent coding and information system, controlled by an expert system and further secured preferably with arrangements based e.g. on biothermal identification for preventing e.g. the passage of unauthorized persons within operative areas, the control system of the invention is capable of providing a significant improvement especially in terms of the safety and efficiency of aviation by eliminating major safety hazards and risk factors associated with traditional aviation. Thus, the control system of the invention can be used for controlling all activities within the operative ground traffic area of an airport from the moment an aircraft has touched down on runway all the way to the moment said aircraft has safely taxied to its designated terminal lot or vice versa.

The non-independent claims directed to a control system disclose preferred embodiments for a control system of the invention. The invention will now be described in detail with reference made to the accompanying drawings, in which

fig. 1 shows basically a general operating principle for a control system applying a method of the invention,

fig. 2 shows further a method of the invention, applying a so-called diffuse spectrum-radio positioning system based on GSM-technology.

A method for operative traffic, said operative traffic, especially operative ground traffic associated with air traffic, being controlled by means of a real-time, automated data processing system, at least some of the operative units present in an operative traffic area, such as aircraft, field, maintenance, and upkeep equipment, vehicles or the like, being at least in an information transmitting communication therewith at least for the identification and positioning of the latter. An expert system 1 is informed about each unit on commission within an operative traffic area, preferably including also persons or groups of persons within the operative traffic area, by means of a radio-frequency operated transmitter system 2 as well as by means of an antenna system 3 enabling a substantially continuous-action positioning, the operative traffic being monitored and controlled by means of a comprehensive expert system 1, preferably making use of so-called soft computing technology, such as a sum logic, a neural network, a neuro-sum logic, chaos theory, genetic algorithms and/or the like for enabling its adaptive or self-learning operation.

In one preferred application of a method of the invention, the expert system 1 is supplied not only with collected real-time information i1, such as that regarding said operative units, but also with information i2 regarding the conditions of an

operative traffic area, such as wind, ice, snow, water, temperature and/or the like factors, for anticipating hazardous situations, such as collision situations or the like, by means of operating models db pre-programmed therein.

In reference to traditional solutions, it is naturally preferable to control operative traffic also by means of guide boards, one preferred application of a method of the invention comprising the use of luminous, such as optical fiber, LCD-, LED-matrix displays 4 and/or the like, which are controlled integrally by means of the expert system 1 especially for providing an active guidance optimally compatible with the situation of each controlled unit.

In a further preferred application of the method, each unit present in an operative traffic area is identified and/or positioned by means of a unit-specific and/or personal detector system 5, such as through the intermediary of remote identification and/or preferably the antenna system 3 or, respectively, by means of a transponder system (TIRIS) enabling the positioning, a fingertip, eyeground identification system and/or the like, based on biometric identification, especially for making use of unit-specific clearances, restrictions, priorities and/or the like programmed in the expert system 1.

In a particularly preferred application of the method, each unit present in an operative traffic area is identified and positioned most preferably by means of a cellular network principle, such as a mobile communicator system included in a mobile communication network consisting of cells containing a base station, the positioning being effected by using a diffuse spectrum-radio positioning system 2, 3, 5 based on so-called GSM-technology. Fig. 2 illustrates one

particular lay-out example for setting up the afore-mentioned diffuse spectrum-radio positioning system. 3', 5' represents in fig. 2 a taxiway shoulder light and a positioning beacon connected therewith. Respectively, 3", 5" represents a runway shoulder light and a positioning beacon connected therewith. kx represents a runway mid-line light. In a type of solution depicted in the figure, each moving/stationary object, or in this example an aircraft fp, fitted with a diffuse-spectrum transmitter 2' emitting an identification code. At this juncture, the runway shoulder lights present in the runway area and the taxiway shoulder lights receive and identify various diffuse-spectral transmissions, operating in accordance with the above-described logic as so-called positioning beacons. In this context, the radio path is provided by a system 2400 - 2450 GHz operating on ISM (Industrial & Scientifical & Medical) frequencies, having a frequency band of 50 MHz and a transmission capacity of < 10 mW. In this type of solution, at the object speed of 0 - 100 m/s, the coordinates are obtained at the accuracy of 0,1 - 10 meters. The scope of surveillance provides a possibility of monitoring all aircraft, vehicles moving in the area, maintenance people walking within the field area etc. In addition, the number of objects within the operating range of a single positioning analyzer may always be as high as 15 objects, whose activated identifications are included in the system data base.

For example, the above-mentioned TIRIS-system is based on an identifier (transponder), which is identifiable and preferably also attachable to an object to be positioned, and on a reader, which in this case is arranged in communication with the position-defining antenna system 2. In terms of technology, the TIRIS-system is constructed in such a way that the

identifier is provided with an antenna element, a micro-circuit containing an identification code, and a capacitor. When subjected to a magnetic field from the reader, the passive identifier is charged and transmits the message contained in the identifier. The identifications are either previously encoded or to be updated in the field of a reader. The identifier receives its necessary operating energy preferably from an electromagnetic field (radio waves) and, thus, it needs no battery or other source of energy.

Referring particularly to the preferred operating principle depicted in the drawing, the control system of the invention comprises a transmitter system 2, operating on radio frequencies and informing an expert system 1 about each unit operating within an operative traffic area, including preferably also persons and groups of persons present in the operative traffic area, as well as an antenna system 3 enabling a substantially continuous-action positioning, the surveillance and control of operative traffic in the control system being effected by means of the expert system 1, making use of so-called soft computing technology, such as a sum logic, a neural network, a neuro-sum logic, a chaos theory, genetic algorithms and/or the like, enabling its adaptive or self-learning operation.

The control system is further preferably based on a self-learning expert system 1, whose information and control channels are preferably constituted by apparatus-specifically encoded high-frequency transmitters 2, and further on an antenna system 3, required for positioning and detecting a set of coordinates to be positioned, and on an active and luminous display board arrangement 4, controlling an operative field area preferably through the intermediary of a so-called intelligent optical

network and based e.g. on an optical fiber/LCD-, LED-matrix.

In a further preferred application, the operative units/persons are linked to the system also by means of a unit-specific/personal detector system 5, such as a transponder system (TIRIS) enabling remote identification and the positioning preferably through the intermediary of the antenna system 3, a fingertip, eyeground identification system based on biometric identification, and/or the like. This enables making use of unit-specific clearances, restrictions, priorities and/or the like programmed especially in the expert system 1.

In a preferred application, the control system includes a diffuse spectrum-radio positioning system 2,3,5, which is preferably based on GSM-technology and whereby each unit present in an operative traffic area is identified and positioned preferably on a cellular network principle, such as a mobile communicator system included in a mobile communicator network consisting of cells that contain a base station.

In an intended application as described above, the control system monitors and controls automatically as well as transmits information independently about all operative traffic action within a field area and, by virtue of this, provides air traffic control and aviators with significantly improved possibilities of taking correct decisions and measures required by a given situation. In addition, the above type of control system increases substantially the capacity of operative field action (landing, take-off, surface traffic, flight maintenance) especially in foul weather conditions, as it is capable of composing an overall picture of all surveillance and sensor points simultaneously. The accuracy is further enhanced, as

the control system is capable of determining and deciding continuously and in real-time all situations and by constantly simulating both mathematically and empirically such situations before they are likely to occur. Thus, an expert system included in the control system is capable of identifying also completely unpredictable events e.g. by alarming the operative staff automatically and by describing the problem as well as by also presenting preferably e.g. graphic and safe, i.e. previously simulated and tested model solutions.

One further advantage offered by the control system of the invention in this context is that it relieves the air traffic control of all control measures regarding aircraft present on the ground and in a normal condition as well as other surface traffic. Hence, the control system concentrates the decision-making especially in a crisis situation on the air traffic control, the expert system, as well as on other monitoring systems associated preferably interactively with the control system, e.g. as depicted in the chart of the drawing. Hence, an expert system of the invention operates as part of the control system by delivering continuous, real-time, graphic information, solution models and suggestions, while leaving, whenever necessary, the actual decision-making to the air traffic control. According to the chart depicted in the drawing, the control system thus collects the real-time information, compares it to a safe decision compatible with the condition of the expert system 1, and produces an alarm about immediate or anticipated discrepancies. The analyzed surveillance information is stored automatically in the data base db.

In certain type of cases, the expert system 1 included in the control system operates automatically by deciding and performing all conventional and non-

hazardous control duties. In addition, it is possible to monitor thereby that the air traffic control performs correctly the ground traffic control operations assigned thereto.

The method and control system of the invention can be further exploited in such a manner that all relevant travelling paths within an operative area are also provided with guiding tapes or the like, controlled in real time by the expert system, whereby e.g. an advancing light or sound effect is used to guide each controlled unit to its proper destination.

It is naturally obvious that a method of the invention can be applied not only in the above-mentioned and -described applications but in the most diverse of contexts, i.e. in addition to ground traffic application, e.g. in a harbour area for controlling and monitoring the passage of boats/ships. Naturally, the operating chart depicted by way of example only represents generally the operating principle for a method of the invention, as it is of course possible to link directly therewith, in addition to the above-mentioned supplementary functions, e.g. an air traffic control radar and monitor info, air traffic control preference decisions, weather observations, etc. Also naturally, e.g. the above-described TIRIS-system can be active as well, whereby, when fitted with a current supply, it will be capable of independently communicating with the expert system, e.g. for the continuous positioning of a moving vehicle.

Claims:

1. A method for operative traffic, said operative traffic, especially operative ground traffic associated with air traffic, being controlled by means of a real-time and automated data processing unit, at least some of the operative units, such as aircraft, field, maintenance, and upkeep equipment, vehicles or the like, present in an operative traffic area, being at least in an information transmitting communication therewith at least for the identification and positioning of the latter, characterized in that an expert system (1) is informed about each unit on commission within an operative traffic area, preferably including also persons or groups of persons within the operative traffic area, by means of a radio-frequency operated transmitter system (2) as well as by means of an antenna system (3) enabling a substantially continuous-action positioning, the operative traffic being monitored and controlled by means of the comprehensive expert system (1), preferably making use of so-called soft computing technology, such as a sum logic, a neural network, a neuro-sum logic, chaos theory, genetic algorithms and/or the like for enabling its adaptive or self-learning operation.

2. A method as set forth in claim 1, characterized in, that the expert system (1) is supplied not only with collected real-time information (i1), such as that regarding said operative units, but also with information (i2) regardin the conditions of an operative traffic area, such as wind, ice, snow, water, temperature and/or the like factors, for anticipating hazardous situations, such as collision situations or the like, by means of operating models (db) pre-programmed therein.

3. A method as set forth in claim 1 or 2, wherein the operative traffic is controlled by means of guide boards present at least in an operative traffic area, characterized in that said guidance is effected by using luminous, such as optical fiber, LCD-, LED-matrix displays (4) and/or the like, which are controlled integrally by means of the expert system (1) especially for providing an active guidance optimally compatible with the situation of each controlled unit.

4. A method as set forth in any of the preceding claims 1-3, characterized in that each unit present in an operative traffic area is identified and/or positioned by means of a unit-specific and/or personal detector system (5), such as through the intermediary of remote identification and/or preferably the antenna system (3) or, respectively, by means of a transponder system (TIRIS) enabling the positioning, a fingertip, eyeground identification system and/or the like, based on biometric identification, especially for making use of unit-specific clearances, restrictions, priorities and/or the like programmed in the expert system (1).

5. A method as set forth in any of the preceding claims 1-4, characterized in that each unit present in an operative traffic area is identified and positioned most preferably by means of a cellular network principle, such as a mobile communicator system included in a mobile communication network consisting of cells containing a base station, the positioning being effected by using a diffuse spectrum-radio positioning system (2,3,5), most preferably based on GSM-technology.

6. A control system for operative traffic, said control system intended for controlling operative traffic, especially operative ground traffic

associated with air traffic, being implemented by means of a real-time and automated data processing unit, at least some of the operative units, such as aircraft, field, maintenance, and upkeep equipment, vehicles or the like, present in an operative traffic area being at least in an information transmitting communication therewith at least for the identification and positioning of the latter, characterized in that the control system comprises a transmitter system (2), operating on radio frequencies and informing an expert system (1) about each unit operating within an operative traffic area, including preferably also persons and groups of persons present in the operative traffic area, as well as an antenna system (3) enabling a substantially continuous-action positioning, the surveillance and control of operative traffic in the control system being effected by means of the expert system (1), making use of so-called soft computing technology, such as a sum logic, a neural network, a neuro-sum logic, a chaos theory, genetic algorithms and/or the like, enabling its adaptive or self-learning operation.

7. A control system as set forth in claim 6, characterized in that the expert system (1) is adapted to process not only real-time information (i1) collected therein and regarding said operative units, but also information (i2) regarding the conditions of an operative traffic area, such as wind, ice, snow, water, temperature and/or the like factors, for anticipating hazardous situations, such as collision situations or the like, by means of operating models (db) pre-programmed therein.

8. A control system as set forth in claim 6 or 7, including guide boards present at least in an operative traffic area for guiding said operative traffic, characterized in that said guidance is

provided by means of luminous, such as optical fiber, LCD-, LED-matrix displays (4) and/or the like, which are adapted to be integrally controlled by means of the expert system (1) especially for providing an active guidance optimally compatible with the situation of each controlled unit.

9. A control system as set forth in any of the preceding claims 6-8, characterized in that, for identifying and/or positioning each unit present in an operative traffic area, said control system includes a unit-specific and/or personal detector system (5), such as a transponder system (TIRIS) enabling the positioning through the intermediary of remote identification and/or preferably the antenna system (3) or, respectively, a fingertip, eyeground identification system and/or the like, based on biometric identification, especially for making use of unit-specific clearances, restrictions, priorities and/or the like programmed in the expert system (1).

10. A control system as set forth in any of the preceding claims 6-9, characterized in that it includes a diffuse spectrum-radio positioning system (2,3,5), most preferably based on GSM-technology, for identifying and positioning each unit present in an operative traffic area most preferably on a cellular network principle, such as by means of a mobile communicator system included in a mobile communication network consisting of cells containing a base station.

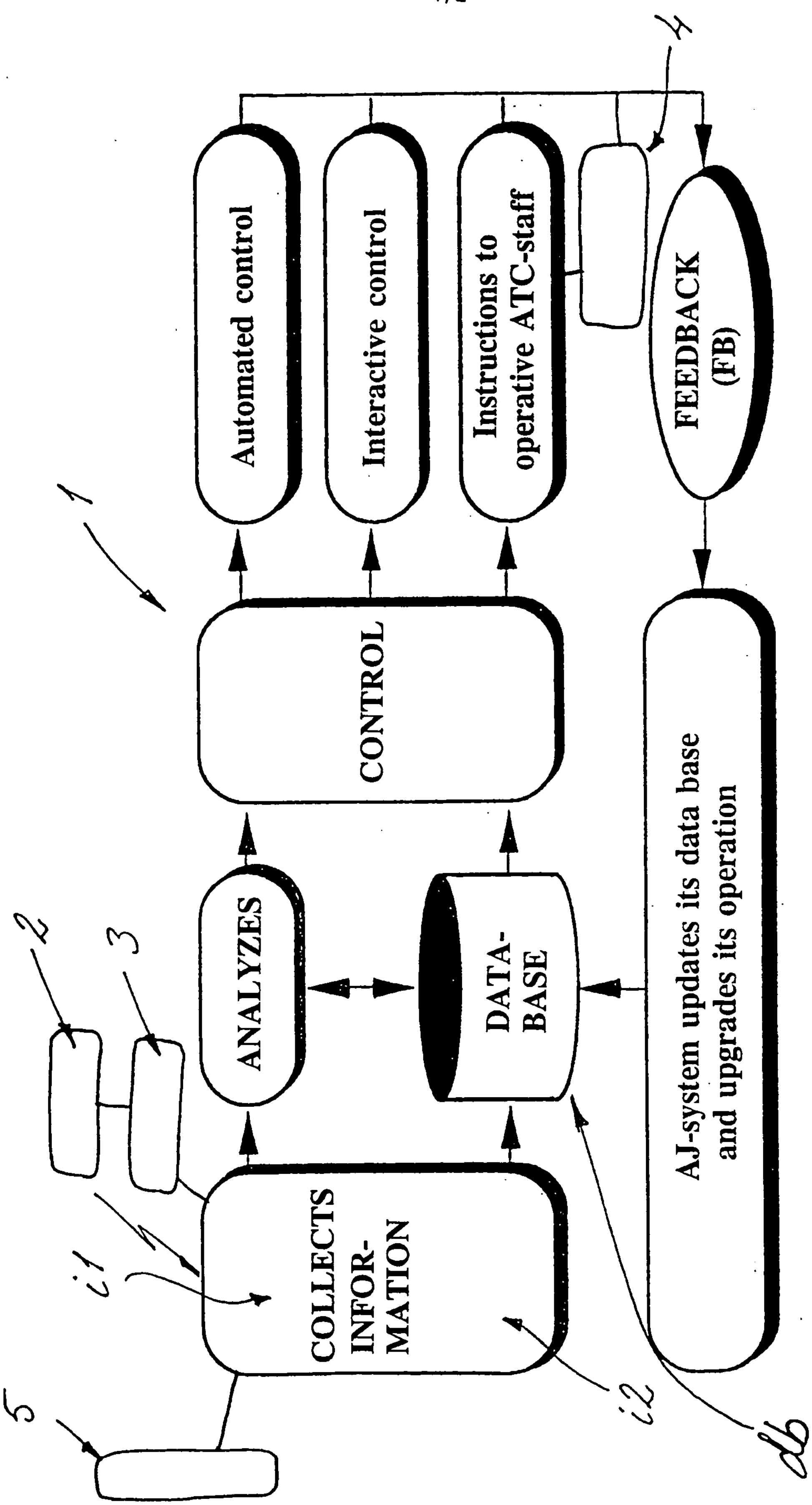
COLLECTS INFOR- MATION
ANALYZES
DATA- BASE
CONTROL
Automated control
Interactive control
Instructions to operative ATC-staff
FEEDBACK (FB)
AJ-system updates its data base and upgrades its operation
1
2
3
4
5
i1
i2
db

FIG. 1

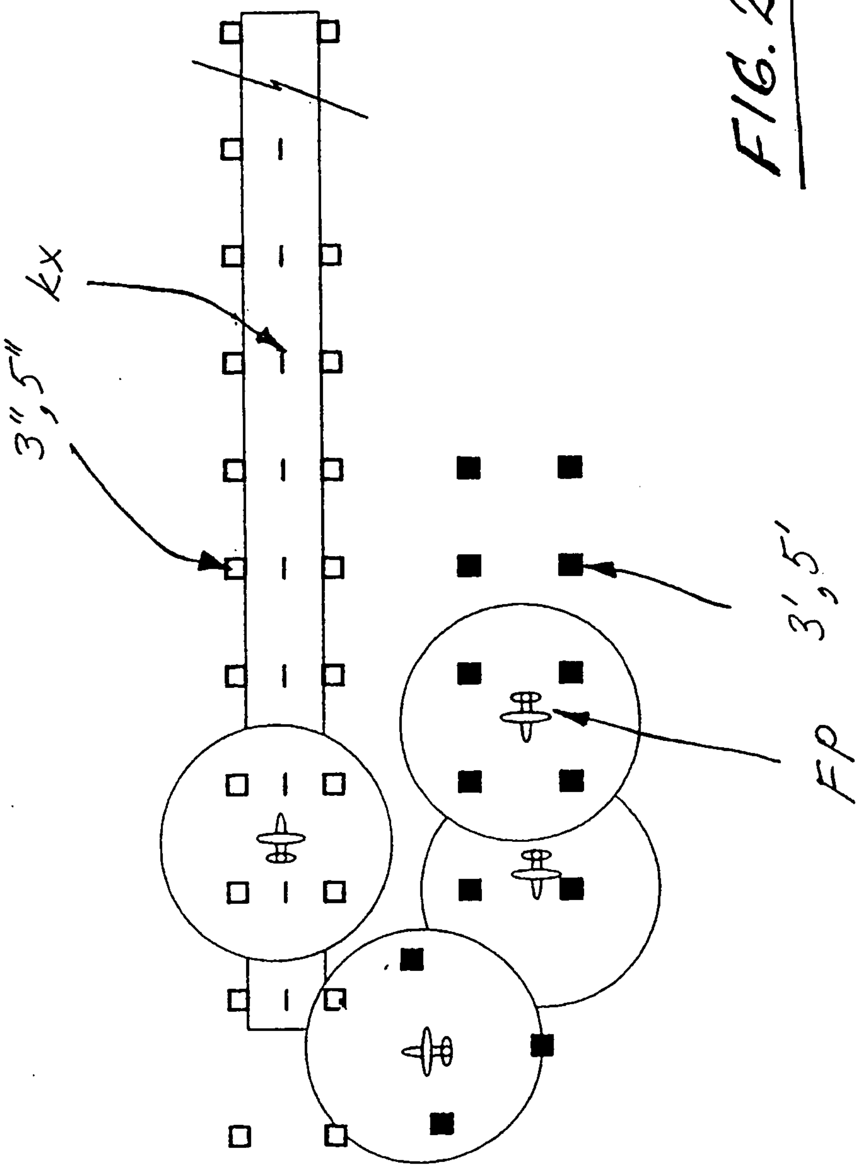

FIG. 2

INTERNATIONAL SEARCH REPORT

International application No.
PCT/FI 97/00281

A. CLASSIFICATION OF SUBJECT MATTER

IPC6: G08G 5/06

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC6: G08G

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

SE,DK,FI,NO classes as above

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

WPI

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	Electrical Communication, Volume, January 1993, Monzel F.-G. et al, "Surface Movement Guidance and Control System", page 51 - page 59, see the whole document --	1-10
A	US 4827418 A (ARTHUR GERSTENFELD), 2 May 1989 (02.05.89), abstract --	1,6
A	EP 0613109 A1 (RAYTHEON COMPANY), 31 August 1994 (31.08.94) -- --------	4,9

☐ Further documents are listed in the continuation of Box C.

☒ See patent family annex.

* Special categories of cited documents:

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" erlier document but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance: the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance: the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
13 February 1998	16 -02- 1998
Name and mailing address of the ISA/ Swedish Patent Office Box 5055, S-102 42 STOCKHOLM Facsimile No. +46 8 666 02 86	Authorized officer Göran Magnusson Telephone No. +46 8 782 25 00

INTERNATIONAL SEARCH REPORT
Information on patent family members

03/02/98

International application No.
PCT/FI 97/00281

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 4827418 A	02/05/89	US 4949267 A	14/08/90
		US 4979137 A	18/12/90
		US 5200901 A	06/04/93
EP 0613109 A1	31/08/94	CA 2114482 A	27/08/94
		JP 6301899 A	28/10/94
		NO 940626 A	29/08/94